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THE JOURNAL OF THE INSTITUTION OF PRODUCTION ENGINEERS

VOL. XXVII - No. 6 - June, 1948

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Contents :

THE RELATIONSHIP BETWEEN RESEARCH AND PRODUCTION ENGINEERING
by W. ARMSTRONG, M.B.E., M.I.P.E., C. L. DAVID, M.I.P.E., and R. J. MITCHELL, M.I.P.E.

THE HISTORY AND DEVELOPMENT OF THE AUTOMATIC LOOM
by H. de G. GAUDIN, B.A., A.M.I.Mech.E.

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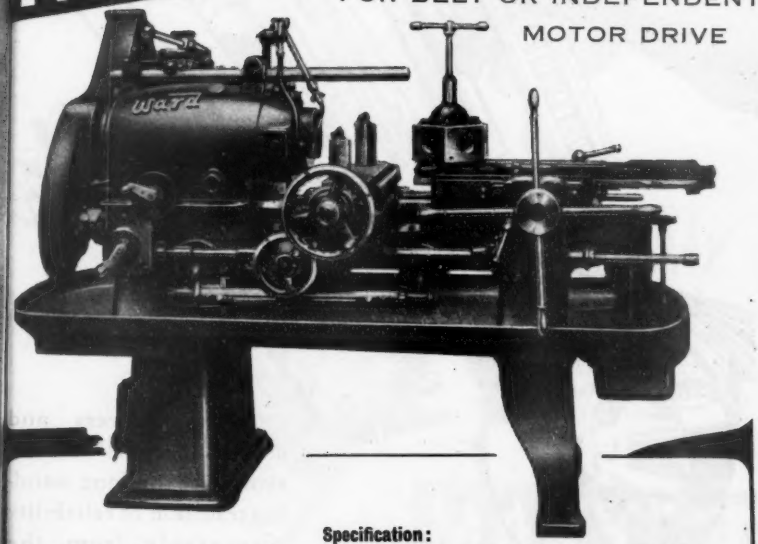

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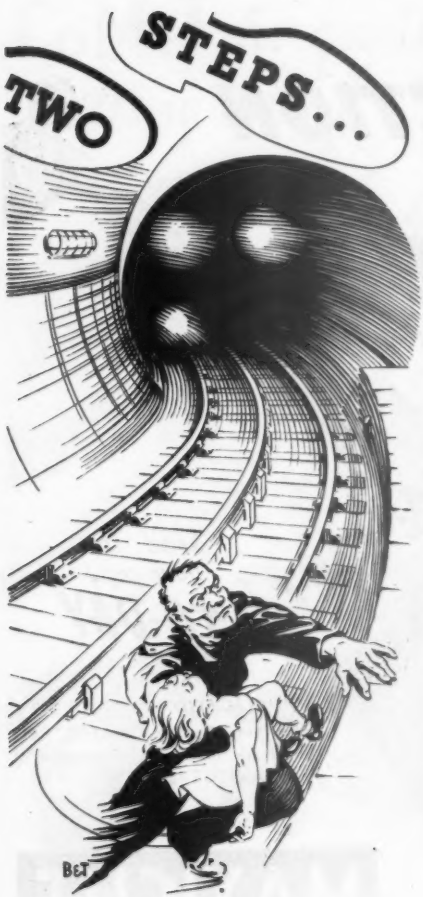

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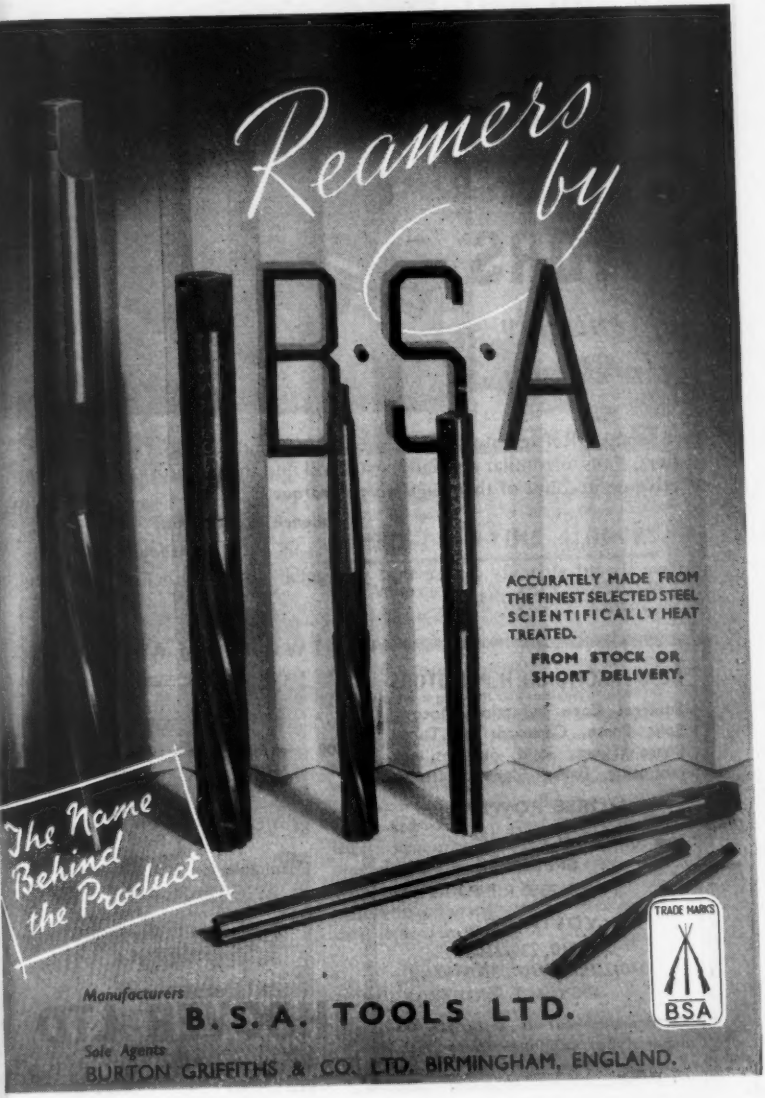
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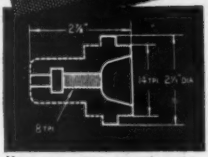

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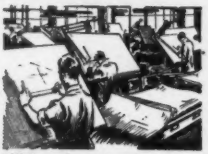

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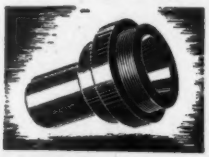

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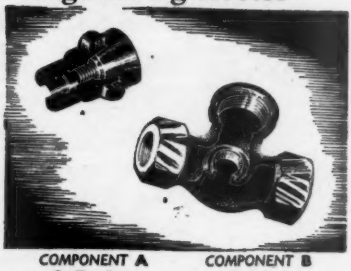

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The Council has for some time past conferred on those who have rendered the Institution long and distinguished service the title of Honorary Member.

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Yorkshire	W. R. Walton, 256, Belle Isle Road, Leeds, 10.

MR. H. W. BOWEN,

O.B.E., M.I.Mech.E., M.I.P.E.

Institution Personalities — 4.

MR. H. W. BOWEN, O.B.E., M.I.Mech.E., M.I.P.E.

MR. H. W. BOWEN, O.B.E., M.I.Mech.E., M.I.P.E.

Mr. H. W. Bowen is Managing Director of E.M.I. Factories Limited, which has taken over the operation of the great E.M.I. manufacturing plant covering E.M.I., "His Master's Voice", Columbia, Marconiphone, Parlophone and H.M.V. Household Appliances, and the many other production sections of the group.

Mr. Henry Wilcox Bowen joined the Gramophone Company as Production Manager in 1940 to organise the tremendous programme of war production which the E.M.I. factories were then about to undertake. Mr. Bowen was awarded the Order of the British Empire in June 1945, in recognition of his services to the nation during the war.

Mr. Bowen has a great reputation for organising ability based on a world-wide knowledge of both electrical and mechanical engineering. He has taken over one of the biggest jobs in British industry as a comparatively young man with mature experience. For many years he was engaged on a variety of big production jobs in Canada and America. His spectacular career in industry, which includes experience in the manufacture of electric cable, mass production of motor cars and all types of electrical equipment, brought him an important appointment in Vickers-Armstrongs of Barrow before the war. This firm was responsible for the manufacture of battleships, cruisers, big guns and a variety of intricate mechanical and electrical equipment.

In the 1914-18 war Mr. Bowen served his country as an airman, joining up as a Flying Officer in the Royal Flying Corps.

Mr. Bowen is a Member of the Institution of Mechanical Engineers, a past President of the London Section of the Institution of Production Engineers and a Gold and Silver Medallist of the Junior Institution of Engineers.

He is a Welshman born at Criccieth in 1898 and imbued with all the vigour, enthusiasm and shrewdness of the Welsh temperament. He has been ideally chosen for these responsibilities, for he has tremendous faith in the future of industrial electronic development. He sees in modern electronic discoveries immeasurable benefits to the Navy and Mercantile Marine, and to industry generally in the countless applications of this amazing new science.

INSTITUTION NOTES

June, 1948

COUNCIL MEETING The next meeting of Council will take place on Thursday, July 15th, 1948, in the Queen's Hotel, Birmingham, at 11.30 a.m.

MECHANICAL HANDLING EXHIBITION AND CONVENTION Modern methods of handling materials in ten industries will be discussed at the Mechanical Handling Exhibition and Convention, Olympia, London, 12th–21st July, 1948, when sixteen papers will be presented by leading authorities.

Industries covered will be coal mining, gas and coke, electric power, railways, foundries, steel, shipbuilding, motor industry, agriculture and cereal and seed industries. Other papers will deal specifically with aerial ropeways, fork trucks, power trucks, hand trucks, time and motion studies and general handling methods as applied to industrial processes of all kinds.

Among the papers presented will be two by Members of the Institution—" Handling in the Motor Industry " by Mr. S. Gilbert, M.I.P.E., and " Time and Motion Study in Relation to Materials Handling ", by Mr. C. Cooper, A.M.I.P.E.

Full particulars may be obtained from the Press Officer, Mechanical Handling Exhibition and Convention, 11, Garrick Street, London, W.C.2.

BRITISH INSTITUTE OF MANAGEMENT The inaugural meeting of the British Institute of Management was held at Senate House, Malet Street, London, at 3 p.m. on Wednesday, April 21st, 1948.

Lt.-Col. Urwick, M.I.P.E., Vice-Chairman of the Council of the British Institute of Management, Sir Norman Kipping, J.P., M.I.P.E., Sir Charles Bartlett, M.I.P.E., Mr. Robert Appleby, M.I.P.E., Mr. T. G. Rose, M.I.P.E., and Mr. Mark H. Taylor, M.I.P.E., all of whom are members of the Council of the above body, were present.

The proceedings were opened by Sir Charles Renold, J.P., Chairman of Council of the British Institute, and addresses were subsequently given by Sir Stafford Cripps, Sir Frederick Bain, and Miss Florence Hancock, Chairman of the T.U.C. The speeches should be of interest to Production Engineers, and members of the Institution may obtain copies on application to Head Office.

BRITISH STANDARDS INSTITUTION The following draft B.S. Specifications have been prepared by the B.S.I. Committees shown, and are now available for comment. Copies can be obtained gratis from the British Standards Institution provided that mention is made in the letter of application that the writer is a member of the Institution of Production Engineers :

(a) CJ(MEE)5475 — First draft revision of B.S.888 : 1940. Slip (or Block) Gauges and their accessories.
Prepared by Committee MEE/59.
Mr. J. E. Baty, M.I.P.E., Chairman of the I.P.E. Standards Committee, is also Chairman, in an independent capacity, of the above B.S.I. Committee.
Latest date for receipt of comments : 16.7.48.

(b) CJ(MEE)5853 — Draft B.S. Methods for Verification of Testing Machines.
Prepared by Sub-Committee MEE/37/7.
The Institution is represented on this Sub-Committee by Mr. C. N. Fletcher, M.I.P.E.
Latest date for receipt of comments : 27.7.48.

NEWS OF MEMBERS

Mr. F. J. Cordwell, A.M.I.P.E., has recently become Works Manager of Whiteley Electrical Radio Co. Ltd., Mansfield.

Mr. H. Gibbon, Int.A.M.I.P.E., is now Technical Director to Messrs. A. Cooksley & Co. Ltd., London.

Mr. W. J. Mason, M.I.P.E., has been appointed Controller of Ordnance Factories, Pakistan.

Mr. C. L. Mudge, A.M.I.P.E., is now Machine Shop Manager for W. A. Baker & Co. Ltd., Newport, Mon.

Miss A. G. Shaw, M.A., M.I.P.E., has been awarded a Gold Medal by the American Society for the Advancement of Management for her work on Time Study and efficiency methods. She is the first woman to be so honoured by the Society.

Mr. J. M. Rattray, A.M.I.Mech.E., Int.A.M.I.P.E., has joined E. & E. Kaye, Ltd., Enfield, Middlesex, as Plant Manager.

Mr. A. G. Rose, A.I.P.E., General Manager of Triplex Safety Glass Co. Ltd., Birmingham, has recently been appointed to the Board of the Company.

VISITORS FROM ABROAD Two members of the Sydney Section are at present visiting the United Kingdom—Mr. H. A. Colton, M.I.P.E., Works Manager of The Standard Telephone & Cable Pty. Ltd., Alexandria, Australia, and Mr. Tom Lord, Int.A.M.I.P.E., Production Engineer of the same company.

Mr. Colton and Mr. Lord have come to this country for business consultations with the parent organisation in London, and hope to attend some of the Institution functions during their stay.

OBITUARY The Institution deeply regrets to announce the deaths of the following members: Mr. W. R. Champion, A.M.I.P.E.; Mr. G. W. Dixon, M.I.P.E.; Mr. Edward R. Dare, Int.A.M.I.P.E.

ISSUE OF JOURNAL TO NEW MEMBERS Owing to the fact that output has to be adjusted to meet requirements, and in order to avoid carrying heavy stocks, it has been decided that the Journal will only be issued to new Members from the date they join the Institution.

IMPORTANT In order that the Journal may be despatched on time, it is essential that copy should reach the Head Office of the Institution not later than 40 days prior to the date of issue, which is the first of each month.

SECTION MEETINGS

The following meetings have been arranged to take place in June and July, 1948. Where full details are not given, these have not been received at the time of going to press.

June

3rd HALIFAX GRADUATE SECTION. A visit has been arranged to Messrs. Cammell Laird, Birkenhead, for 2.00 p.m.

8th WOLVERHAMPTON GRADUATE SECTION. A Film Show—" Wheels Behind the Wheels "—will be given at the Walsall Technical College at 7.15 p.m.

15th LONDON SECTION. A visit to the Ferguson Tractor plant at the Standard Motor Company's Works, Coventry, has been arranged. The party will leave London at 8.50 a.m.

19th COVENTRY SECTION. A dinner has been arranged at the Marlborough Hotel, Leamington, followed by a visit to Stratford Theatre. The party will leave Pool Meadow at 5.15 p.m. Dinner—5.45 p.m. Theatre—7.30 p.m.

22nd LONDON SECTION. A visit has been arranged to Kodak, Ltd., Harrow, Middlesex, at 2.00 p.m.

July

6th WOLVERHAMPTON GRADUATE SECTION. A film show—" After the Lord Mayor's Show "—will be given at the Willenhall Evening Institute at 7.15 p.m. The film deals with the workings and requirements of a modern road sweeper.

THE RELATIONSHIP BETWEEN RESEARCH AND PRODUCTION ENGINEERING

by W. ARMSTRONG, M.B.E., M.I.P.E., C. L. DAVID, M.I.P.E., and R. J. MITCHELL, M.I.P.E.

Presented to the Institution of Production Engineers, Yorkshire Section, December 2nd, 1946.

PART I—by W. ARMSTRONG, M.B.E., M.I.P.E.

I would like to open my remarks with a quotation from the Presidential Address of Sir William Halcrow to the Institution of Civil Engineers :

" The well-being of the world largely depends upon the work of the engineer. There is a great future and unlimited scope for the activities of members of the profession ; new works of all kinds are and will be required in every country in the world, and for the young man of imagination and keenness I cannot conceive a more attractive profession. Imagination is necessary as well as scientific knowledge. The greater the freedom and independence engineers can retain in the practice of their professional art and skill, the greater will be the real progress made."

Research implies progress and its widest object should be to prepare the way to produce goods to give better performance, of better quality, at a price which will benefit a greater number of people. Research is not complete in itself, but must be considered in relation to other branches of an industrial organisation, particularly production.

From an ethical point of view, the quality of research varies considerably. That which merely devises cheaper methods of production with the object of increasing profits is not of such a high standard as that which aims at improving quality without increasing cost or selling price.

FUNCTIONS OF A PRODUCTION DEPARTMENT

It is comparatively easy to explain the duties of a Production Department—its very name implies its function—and those engaged in that department often consider that they are the backbone of the organisation—a view with which we must all agree, because without production, the whole structure collapses. At the same time, it would be extremely unwise for a production executive to belittle the importance of research work. Close co-operation between research and production must yield results which will be beneficial to all concerned. This

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co-operation must be founded upon respect for each other's ability in his own sphere, and an appreciation of each other's difficulties. The major problem will be for the Research Department to justify its existence in the eyes of the Production Department, and with this in view it behoves research to produce practical results.

FUNCTION OF A RESEARCH DEPARTMENT

A Research Department has many worthy functions to perform, of which the following are a few :

(*a*) To overcome present difficulties in production.

(*b*) To investigate alternative materials and methods.

(*c*) To investigate customers' problems and complaints.

(*d*) To probe future developments and study the trends of shifting demands.

Probably, if this latter function were clearly understood by other departments it would be realised that the Research Department may be very largely responsible for a continuous flow of orders in the future.

At this point I would like to express an opinion as to the conditions which will produce the best research work and encourage the best type of research worker.

In the first place, initiative must be the key note of the research worker ; consequently State-controlled establishments should be avoided except where problems of great magnitude are being experimented upon, such as the harnessing of atomic energy, where enormous financial resources are required. Research cannot be carried out by regimentation and if a research worker is continually being called upon to submit to higher authorities lengthy reports upon what he has done, what he is doing, and what he proposes to do and why, he cannot give of his best, particularly if he knows that upon the plausibility of his report depends the grant of further funds to enable him to carry on. In times of war, when finance appears to be unlimited and the stress of emergency is great, important results have undoubtedly been achieved, but these conditions are exceptional. For my own part, I would rather carry out my experimental work in a shed at the bottom of the garden than in a State-controlled establishment. At the same time, unlimited freedom may not be good, as this may lead to the pure theorist soaring into the clouds and remaining there, living a life entirely divorced from the hard facts of practical production, flitting from theory to theory, and never finishing anything which could truthfully be said to have contributed to the well-being of the profession.

It will be argued that no private concern could afford to run a research department that did not produce practical results. This may be true in times of keen competition, but during a period when the order book is full to overflowing and the method of taxation encourages luxuries, it is quite possible to find a research laboratory

staffed by workers with undoubted theoretical ability of a very high standard but with no link with production and with no practical experience. These conditions are not good for anyone concerned. This type of research department will be looked upon as an expensive luxury by other departments, particularly the works, and its leisurely atmosphere may spread. No doubt I am laying myself open to criticism here because it is often argued that a scientist should not be hampered by practical difficulties.

POSSIBILITIES OF JOINT RESEARCH

Groups of manufacturers in one industry may run a joint research organisation. This undoubtedly means that more money is available for equipment and a larger staff. The principle appears good theoretically, but to me personally the contact between a member firm's production department and a joint research laboratory seems somewhat remote. It would seem also that work carried out under these conditions would be of a general rather than a particular nature. There is also the risk of the larger firms reaping the greater benefit, although their contribution may only be the greater financially.

Where firms are large enough to carry out their own independent research work, the conditions could be ideal, provided the right men are appointed. Apart from ability, there should be keenness and a pride in the firm and its products.

It is admitted that one of the functions of management is to foster co-operation between departments and this is particularly important between research and production. At the same time, there is one person whose advice and opinion are of greater value to both these departments. I refer to the technical representative. The man who is in personal contact with the user sees at first hand the products of this firm in use under normal working conditions and is in a position to collect information regarding difficulties of operation, and possibilities of improvement, and also to gain knowledge of the comparative performance of his own firm's and competitors' products.

Under these conditions of independent research, a firm may investigate improvements in their products and carry out experiments on new methods and designs without having their work broadcast. This leads to healthy competition between manufacturers of similar products and progressive results of benefit to the user.

So far, my remarks have been concerned with separate research departments run as such and staffed by personnel with no direct responsibility for production, but I suggest that in smaller concerns much valuable progressive work can be carried out by works personnel, particularly in the tool room, provided that some member of the firm—possibly in the drawing office—can bring sufficient technical knowledge to bear upon a problem to reduce trial and

error to a minimum. Experimental work carried out under these circumstances has a more personal flavour and results are likely to be achieved more quickly because production personnel are, or should be, brought up in an atmosphere of " getting things done ". There is the possibility also of utilising the services of apprentices who are showing ability and a flare for ingenuity. Encouragement and guidance combined will yield healthy results.

We must not lose sight of the fact that manufacturers of materials, taking steel as an example, are always willing and anxious to pass on to users the benefits of their own research departments. In this connection, it would appear that something has run slightly out of balance somewhere, because a glance at any steel maker's catalogue will reveal about three or four times as many different qualities as are really necessary. Is this a case of steel maker's laboratories running amok, or are the metallurgists employed by steel users responsible for this state of affairs, which can only hamper rather than assist production ?

THE RIGHT APPROACH

In conclusion, I would ask you, gentlemen, whether you have leanings towards research or production approaching each other in a friendly manner, with the main object of solving problems as they come along and planning together for the future. Don't be reluctant to relinquish an idea when a better one is brought forward. Remember that the man who clings grimly to any one idea has usually very few to cling to.

Don't lay claim too strongly to any particular improvement, because when all is said and done progress is a very gradual process and each step forward is usually due to the work of many. Above all, remember that we spend most of our waking hours amongst our business associates and it behoves us to make this period as pleasant as possible.

PART II—by C. L. DAVID, M.I.P.E.

I would like to say at the outset that a certain amount of repetition of what has been said just now may be unavoidable. Whilst we all had some time to prepare our contribution to this discussion, we rather seem to have made a point of not comparing notes. This will naturally have the effect that we may approach the subject from different angles, as would certainly be desirable. On the other hand, if we have hit on approaching this discussion on parallel lines, it may be a little boring for you, but it will give us the satisfaction that great minds have been thinking alike.

TERMS OF REFERENCE

I should like to start with an attempt at clarifying our terms of reference. The first question, therefore, is : " What is a Production Engineer ? " Neither the O.E.D. nor the Encyclopædia Britannica, which I thought could help

us there, gives a direct definition. I will therefore fall back on the definition used by Dr. Schlesinger when he lectured some time ago about University Training for Production Engineers. It is the definition of the Central Register : "A Staff Engineer who normally holds in any engineering works a position of authority involving responsibility for executive management or control (above the rank of foreman) of any technical function pertaining to production " ; or to put it more briefly : " a man knowing the technique of production, in a position and with the ability to apply his knowledge." This knowledge is based on his practical training and his technical education. In his practical training he learns from his own experience, his own mistakes in particular, and from his immediate surroundings. His technical education should give him the benefit of the combined experience of a great many other people, experience which has been brought into some sort of system. Incidentally, " education " has once been defined as " what remains after you have forgotten all you have ever learned ", and I think this applies to technical education too !

Every Production Engineer probably comes daily across problems where he feels he could do with some more definite and detailed information, instead of vague generalities allowing wide margins for errors, assumption and guessing ! This is where the need for research becomes evident — not that the Production Engineer is particularly interested in research as such. For him, it is only a means to an end, inasmuch as it provides him with useful information to help him with his job of producing material things better, in greater number, with the least possible effort and therefore at lower cost. He wants the fruits of research preferably in some tabulated form, some reference sheet, some card index, some super Mrs. Beeton, to be referred to quickly when some difficulty arises.

DEFINITION OF RESEARCH

What then is research ? The O.E.D. defines it as : " an investigation directed to the discovery of some facts by careful study of a subject " and as " a course of critical or scientific enquiry." I should like to underline two words in that definition—*facts* and *careful* study. Both are the essence of real research. We have all heard of the distinction between ' pure ' research—something rather lofty—and ' applied ' research, something not quite first rank. Now, whatever the difference between ' pure ' and ' applied ' research—and there *are* obvious differences in starting point and aims—there is *no* difference in the methods of research, nor, for that matter, in the necessary abilities of the research worker. There are obvious differences in mental make-up between the two types, but it is not so easy to say which is more important. Incidentally, historically speaking applied research and science are probably older than the pure brand. When

old man Archimedes jumped out of his bath shouting " Eureka ", he may have thought as much of applying this knowledge of hydrostatics to discover counterfeit gold coins as he was interested in the learning itself. One of the biggest incentives in early chemistry was the search for a conversion of base metals into gold—and not for scientific reasons only.

To come back to our definition of research ; we want facts. How do we get them ? By observation of what happens under very definite conditions. It follows from this that it is most essential to have a careful preparation before carrying out any tests and observations. In particular, it requires a careful selection of the equipment, notably the measuring instruments. It is not enough to know that these instruments were once upon a time correct. It is essential that they are regularly checked against masters, preferably before and after every series of important tests, to see whether any variation has occurred in the meantime. It is wrong to rely on any one particular instrument and conclusions might be entirely erroneous if they are based on wrong measuring instruments. Further, it is important to realise the accuracy of the instruments over their whole range, and the suitability of the instruments for a particular job. The fact that a dial indicates ten-thousandths of an inch does not always mean that it will measure to that degree of accuracy.

IMPORTANCE OF RECORDS

Whilst carefully preparing the equipment—which frequently takes very much longer than carrying out the test itself, and incidentally for the research worker concerned can be much the more interesting part of the job—it is essential that a clear record should be kept where all relevant facts are entered.

This is particularly important and not so self-evident. The reason for it is not to fill in reams of paper uselessly, but to enable anybody with the required skill and knowledge to check on doubtful results and to allow an exact repeat. This applies equally to a test itself, and not only to the preparation where every alteration should be recorded. Here we come to a further point of fundamental importance : among all the many variable factors, more than one should never be altered at a time, otherwise it will be impossible to assess any individual influence.

It is the greatest drawback of ordinary workshop haphazard trial and error methods that measuring instruments are inadequate and unreliable, two or three variables are altered at the same time, and no records are kept. The result is frequently that the same ground is covered again and again without benefit to anybody and it is exceedingly difficult to reproduce a definite set of circumstances. The reason is, of course, that the shop never has the time to look for

the ideal arrangement ; as long as a satisfactory answer to a given problem can be produced, nobody worries too much about why some other previous set-up failed.

The results of any series of observations should be discussed in a report and the necessary conclusions drawn and illustrated, preferably in a handy form, tabulated or as curves in a graph showing the tendencies. Coupled with this should be a recommendation as to what action should be taken in similar circumstances. Often the work of several months can be summarised in one or two graphs showing the influence and importance of one or two variables.

PUBLIC OR PRIVATE RESEARCH

Having touched on the meaning of research, and how it should be carried out, a very important and controversial question arises : where should it be done and who should do it ? Should it be done publicly or privately ? The answer is both. Research by public institutions is obviously preferable where questions of general interest are concerned, whilst private research necessarily recommends itself to questions which are only of interest and importance to a few people or firms, or in a question of general interest where an answer is required relatively quickly. The great drawback of private research is the waste of effort through duplication of investigations which are not made public owing to trade rivalry. From a general and national point of view it would be more satisfactory if research was carried out by public institutions, and if there was a certain amount of planning of research activities. On the other hand the question of payment must be taken into account. No doubt many firms would be prepared to pay for research work even—or particularly—on questions of general interest, provided those firms are the main or only beneficiaries. On the other hand, they will be far less interested in that same problem if results are going to be public property and will be shared by their competitors. This attitude is only natural, though it might be argued that it is wrong in the long run.

One word here about private research. A test laboratory might be very well equipped with all modern instruments, but it is not necessarily contributing to research, however important its work for the firm concerned may be. Merely to find out and to say that a certain product or process is not suitable is barely touching the fringes of research. The important distinction is : is an attempt being made to find out the reasons why a certain failure occurred ?

Personally, I would suggest that if facilities for public research exist, or can be created—State institutions, or trade associations, or perhaps private laboratories whose main business is research —there is comparatively little need for research in individual firms, whatever their size. When difficulties are encountered which require scientific investigation and experiment, it might be simpler

and more advantageous to consult such institutions outside the firm's own organisation. One particular advantage of such an arrangement would be the likelihood of a less biased opinion. The research worker, who is only human, would be less likely to find results which confirm the Managing Director's prejudices or pet theories if he were not attached to a particular organisation.

Perhaps the best private research station is one where the individual worker can get a fair amount of publicity, through results being published in recognised trade journals or scientific publications. An outstanding example is the Research Department of a well-known Milling Machine Company, whose research workers publish results under their own names—results which are usually of general interest and value. The published activities of a good Research Department can add considerably to the prestige of an organisation.

SPECIAL PROBLEMS

I should like to add a few words about the special problems of Production Engineering Research—problems we all feel ought to be tackled generally. They come firstly under the heading of production processes—cutting speeds, feeds, cutting angles, cutting forces, vibration of machines, tools and workpieces—all these to be established for various materials and cutting tool metals ; questions of cutting lubricants and coolants ; relation between finish and stock removal and speeds ; tool life between regrinds for various contributions of feeds, speeds, cutting angles ; suitability of certain processes for a given job ; comparison of interchangeable processes ; planing, shaping, milling, or turning against milling, thread cutting, milling, grinding or rolling ; machinability as a function of hardness, ductility and yield strength ; economics of processes ; finish as function of stock removal, tool life and tool setting time.

A second heading would be questions of production organisation such as suitability of paper work and office procedure—selection of people and jobs ; suitability, advantages and drawbacks of different wage systems ; time rate against piece work ; usefulness and economy of overtime or otherwise ; optimum working time without a break ; questions of fatigue in different jobs ; duration of break ; working in gangs or individually ; questions of inspection—statistical methods ; time and motion study technique and results ; questions of lighting, ventilation, heating, storekeeping, transport. All these are only a few items taken at random and indicating the scope of problems on which research is continually necessary.

Now, a good deal has been said about research, and a good many people have been talking about it without quite realising who is going to do all this. What sort of people are the research workers themselves, and what are the suitable qualifications ? One thing is

certain. Most people who have the drive, energy, restlessness and ability to be successful Production Engineers are temperamentally not best suited for research work. Two or three qualifications will stand out above the rest. Firstly, a highly-developed critical sense, including self-criticism and distrust, to the point of pessimism, of anything which cannot be proved by facts or sound reason. As has been said, very rightly, doubt is the beginning of all science! Secondly, great patience to take meticulous care over small details, and to be ready for repetition and cross checks to establish a proof. Thirdly, integrity—an ability not to suppress results which contradict a preconceived idea or theory, and finally, an ordered and systematic mind to distinguish and separate the different variables, observe and record them.

ESSENTIAL QUALITIES

These qualities, together with the obviously necessary intelligence and knowledge, are not so easy to find. We have to remember that research scientists are not angels, and are not much less human than the rest of us. They are, on the whole, perhaps not quite so keen on financial rewards, but they do want recognition and publicity and they are perhaps a little touchy regarding their professional prestige—which does not necessarily mean academic degrees or titles. Their desire for publicity is certainly not unhealthy, because it stimulates interchange of ideas, even though the motive may sometimes only be jealousy or vanity.

One further quality ought to be mentioned ; that is the inability or reluctance of scientific workers to keep to timetables, a reluctance which they share with designers and draughtsmen. This brings me to the somewhat overdue conclusion of my remarks. A lot has been, and is being said about the value and importance of research. There is no doubt that it is very important, but it is far more important still to be ready and willing to make use of all the new knowledge, to employ Production Engineers and Designers who are capable of assimilating and willing to apply new information—people whose minds are not closed to fresh ideas, and who keep an eye on new developments and research. This, I contend, we can all do and ought to do, without any great expense on equipment and without any specialised knowledge of research technique, for the greater efficiency of everyone engaged in production. Unless this is done, all talk about the need for ' research ' and ' scientists ' remains talk, and all efforts made on research are wasted.

PART III—by R. J. MITCHELL, M.I.P.E., M.I.Mech.E., M.I.E.E.

I find this subject on which the Institution has asked us to present our thoughts somewhat puzzling, since no engineer can fail to

perceive the intimate relationship between research and production, a relationship which is as close as that of warp and weft.

There are some lines of Kipling which run—I hope my quotation is correct :

> " Romance is dead, the cynic said,
> And all unseen
> Romance brought in the nine-fifteen."

Kipling reminds us that a railway seen through the imagination *is* embodied romance. I suggest that production engineering is by a similar vision embodied research ; nearly every operation, machine, and product has been subjected to scientific analysis by a legion of inquisitive and inventive minds extending back, say, at least two hundred years.

DIVISION OF RESEARCH

Research is by general consent divisible into two main branches ; that part dealing with fundamental enquiries such as Faraday's immortal investigations on the relation between electricity and magnetism, and what might be described as functional research, of which a good example was Air Commodore Whittle's experimental attack on the jet motor problem.

Fundamental research requires the highest attainable measure of imaginative inquisitiveness, together with a passion for the truth at any cost. Functional research is much nearer the ground, though no less important to human welfare, and demands the largest possible background of ancillary knowledge, as for example such an objective as designing a high voltage D.C. generator—a job which has lately been accomplished in several countries, resulting in our old friend the Wimshurst static machine growing up into a fully-fledged engineering machine giving outputs up to 100 k.W and potential differences up to 1,000,000 volts.

There can be no question that fundamental research work is of absolutely vital importance to the community, since by its findings an infinite variety of applications become possible.

Fundamental research work cannot be done to order or impatiently hurried ; it awaits inspiration and in a sense arrives almost by accident—the accident of a particular human being possessing the urge and the flair to search out the truth of some aspects of the phenomenal world around him. Such activities are best or most likely encouraged by unstinted endowment of university laboratories. Industry, taken by and large, cannot be trusted to handle fundamental research in the best interests of the community.

Our Institution has widely identified itself with basic research in relation to cutting tools and machinability. This is a difficult subject —Taylor worked for 26 years on the experiments which are summarised in his work " The Art of Cutting Metals "—and it

demands both enthusiasm and great judgment, together with immense patience. These faculties have been fully demonstrated in the pioneer work of Dr. Schlesinger, and it would appear likely that the team who worked with him will throw considerable light in many dark places in the practice of cutter-workpiece technology.

A STORE OF KNOWLEDGE

It should not be forgotten that today production engineers have at their disposal, if they are sufficiently interested, a vast amount of knowledge collated by the specialist firms engaged in such branches as abrasive wheels, special steels, carbides and hard alloys in general, electronics, plating processes, and so on, which knowledge appears not always to be as well disseminated as the firms whose research work is made available would like. The fault lies not with the specialist firms, but with the lack of curiosity which is quite frequently encountered.

Before improvements can be introduced into any works, there must be at least one person who has or makes the time to become informed of progress a little in front of immediate needs. This aspect of the research relation cannot be overstressed, especially as applied to the numerous small and medium-sized establishments which comprise the majority of Britain's manufacturing resources. The special products alluded to above are the end-products of very precise research work indeed and, after all, the production engineer in his daily job is concerned with end products—i.e. getting the job done—and only in his quiet moments can he pause to cogitate on the inner truths underlying the practical externalities.

The study of these inner truths lies in the domain of fundamental research, a good example of which is the operation of atomic hydrogen welding, wherein are encountered processes sufficiently complex to keep a team of engineers, metallurgists, physicists, chemists—not to mention mathematicians—busy for years. But the end product—the result of the research work which has made the technique and the tests available—is there for the engineer. He should first become aware of it, find out broadly how it operates, then form a judgment of its place in his own work, and finally, apply it the moment it suits the job.

ASSISTANCE FROM TECHNICAL COLLEGES

In my opinion, a vast unused potential of research activity lies in our senior technical colleges, but many and extensive changes must be made in their organisation and equipment to enable them to be of the fullest use to industry. Technical colleges are for the most part braked both financially and in regard to staffing, equipment and freedom of action, by the executive personnel. The central technical college of any large city in Britain should be a focus of mechanical, electrical and scientific facilities on a scale which would enable any problem

concerned with predominant local industry to be investigated in a comprehensive manner, the college staff being invited to walk in and out of local works to maintain technical liaison with actual manufacturing conditions so as to keep their research in line with practical limitations. I do not suggest that every works should keep ' open house ' in regard to all its operations—most establishments have their confidential reserves—but that a policy of ' come in and see ' would in the end benefit all without loss to any who participated in such co-operation.

Technical college scientific executives should be supplemented by men from industry from time to time, and should themselves have time free from actual routine teaching to enable them to take a very active part in production engineering research activities.

As to the problem of " what first ? " and " for whom ? ", it seems to me that the local sections of our Institution could helpfully co-operate with such technical college officials to consider, decide, and implement a plan of work based on the agreed need for each item and its order of importance in relation to local industry. Work which might not be immediately published could also be undertaken for firms willing to pay adequate fees for such assistance. Where complete and permanently exclusive advantage was required, the fees should be on a much higher scale—a sort of patent basis. Unless our technical colleges are treated on a vastly less ungenerous scale than at present, the difficulty of persuading first-rate men to enter the academic side of engineering will greatly increase.

An aspect of technical college activity which so far has received almost no attention is that of providing industrial museums, in which should be shown not only representative mechanism relating to local industry, but which should also contain a section where the very latest developments of technology are demonstrated, so that students of all ages could with the least possible time-lag acquaint themselves with the accomplishments of their age, including the technique of production in all its phases.

This technical museum would really be a continuously running exhibition very much on the lines of the Science Museum in London, but having a local bias. " Cost ", did you say ? My answer is that a fraction of the money now wasted on advertising—I don't say it is *all* wasted—would pay for this venture and enable it to be a vivid presentation which, both as an educational instrument and as an industrial shop window, would reap dividends not only for industry, but for the community.

WORKING FOR THE FUTURE

Our minds, in these times, are intensely concerned with the future, and more particularly the near future. The outcome of the next few years will determine whether a fuller life or an existence of drudgery is to be our lot. An immense

national effort—intellectual, moral, and physically energetic—is required of us, and the seniors in age and experience should lead the steps of the juniors in such a way as to kindle in young minds the ambition to do their part, with all their might of mind and body, to set our ancient civilisation on paths which lead to honour and respect among nations.

We members of the Institution of Production Engineers have plenty to do in looking after our own section of this immense problem. We note that in 1946 sixty-eight entrants sat for our Graduateship examination and that forty-one of these failed—lamentable indeed in a nation possessing well over 100,000 workshops where production is being carried out.

Here is a job where Personnel Managers can help the nation, and by co-operation with our Institution encourage young men of likely calibre to study for our Graduateship examination as a first step towards the knowledge which will enable them to find out what they want, and work to get it. Through no fault of their own, Personnel Managers often find themselves in charge of a " grievances bureau ". This latter function should be a very minor part of a Personnel Manager's concern, whilst instruction and education should be his preferred and major activity. Such a movement within industry would be a research of equal importance to any which might be envisaged in the field of mechanics and applied science in general. Its need is imperative and urgent.

To sum up, I suggest that as regards the field of knowledge described as engineering, there never was in man's history such a marvellous and diverse array of flowers waiting to be plucked for his use and satisfaction. The garden, however, lacks a sufficiency of signposts to encourage the curious-minded to wander down the paths (of education) and profit by the riches now growing. Special training (job-craft) and education in the broadest sense are lamentably lacking. Our duty as an Institution is to concentrate on rectifying these defects with all the zeal of a crusade. That would indeed be " the research magnificent ".

THE HISTORY AND DEVELOPMENT OF THE AUTOMATIC LOOM

by H. de G. GAUDIN, B.A., A.M.I.Mech.E.

Presented to the Institution of Production Engineers, Yorkshire Section, February 2nd, 1948.

In this country today there is a wider interest in the question of automatic weaving machinery than there has ever been. Automatic looms are the subject of many discussions, of articles in trade journals, and even in the lay press. There have been Government enquiries into the question of the production of automatic looms. Why is there this interest? There are three main reasons :

(1) There are not enough weavers in the industry, and the intake of new recruits is insufficient.

(2) Wages in the textile industry have altered a great deal since the war and this has increased the wages of the weaving operative.

(3) Manufacturers are obtaining a very much better price for the cloth which they produce, and, although we are supposed to be approaching a buyer's market, these prices will probably hold for some time.

The chief results of these three reasons for increased interest are that it becomes essential for one operative to attend to more machines in order to maintain volume of output ; it is essential on account of higher wages that each operative should produce more fabric, and lastly, because cloth is selling at a better price, the manufacturer is in a better position to pay more for new machinery.

DEVELOPMENT OF WEAVING

Most modern machinery is the result of years of development and experiment, and the automatic loom is no exception. To understand fully how the automatic loom of today has reached its perfection, it is important to go back many years.

A woven fabric is the result of interlacing a single weft end of yarn over and under a number of warp ends of yarn running in a direction at right angles to the weft. Many hundreds of years ago the weft end was inserted by use of a stick with a hooked end, and the weaver passed the weft through the warp ends first in one direction, by means of this hook, and then in the other. The speed of operation was at the rate of one pick, or one insertion, of weft per minute.

This stick with the hooked end was then replaced by what is

known as a " shuttle ", and there is no record as to when the shuttle was first introduced. This shuttle was thrown by a weaver on one side of the loom to a weaver on the other side, who, in turn, threw it back again. This arrangement necessitated two weavers to each loom, but it was possible to increase the rate of production to about 16 or 20 insertions of weft per minute.

It was only in 1733 that John Kay invented the Fly Shuttle. By this means one weaver was able to throw the shuttle first from one side and then from the other without assistance, and the speed of production of cloth was greatly increased to something like 100 picks or insertions of weft per minute.

APPLICATION OF POWER

The next most important development was the application of power to a loom. This was introduced in 1785 by Cartwright, when instead of the weaver throwing the shuttle, it was mechanically propelled. Development was slow, however, and even in 1813 there were still only 2,400 power looms in Great Britain.

During weaving it is important that the fabric should be well stretched while the pick of weft is being inserted. On Cartwright's loom this was carried out by the weaver hooking weights on to each side of the cloth ; as the cloth was woven and rolled down over the front of the loom, it was obviously necessary for the weaver to keep replacing the hooks, ensuring that the maximum pull on the cloth was at the point nearest to the insertion of the new pick of weft. This process called for a great deal of attention from the weaver, and it was only in 1816 that the device known as a Rotary Temple was invented, which replaced these hooks and relieved the weaver of her work. This invention immediately made it possible for one weaver to look after two looms.

By 1840 another important invention had been introduced—the ' Weft Fork '. This sensitive mechanism was used to detect a breakage in the weft yarn and to stop the loom. The result was that in this country the speed of a loom was increased, and in America it remained at about 150 picks per minute, but the number of looms was increased from two to four per operative.

Between 1840 and 1895 there were few important inventions, but there were many improvements in the design and build of this crude machine called a " Loom ".

There were also many improvements in the spinning and preparation of the warp and weft yarn, so that by 1895 the number of looms per weaver in this country had increased to four, at a speed of 220 picks per minute, and in America the number of looms per weaver was eight, at a speed of 190 picks per minute.

FIRST AUTOMATIC LOOM

It was in 1894, 54 years ago, that the Northrop Automatic Loom was first introduced in America. The number of looms per weaver was increased immediately to 16, and the loom speed of 190 picks per minute was maintained.

Today, after 53 years of continuous development, the automatic loom has become the recognised weaving machine for almost every woven fabric, and there is almost no limit to the number of machines that can be attended by one supervisor. In this country there are installations of 40 looms with one supervisor, on the Continent of 60 looms per supervisor, and in America it is common to find 80, 100 or 120 looms being supervised by one operative.

In order to study more closely the development of the automatic loom we must go back to 1886, when three brothers of the Draper family, well-known textile machinists in their day, decided to design and build an automatic loom. They gave the job of carrying out this work to two men, Rhoades and Northrop, who worked on the idea of mechanically changing the shuttle in the loom. When the weft supply in one shuttle was exhausted, this shuttle would be replaced by a new one with a fresh supply of weft yarn. Two years later, Rhoades completed his shuttle-changing loom, followed by Northrop in 1889 with his loom, and fairly successful tests were carried out with these machines in the Fall River area of New England.

James H. Northrop was born in Keighley on 8th May, 1856, and went to America at the age of 25. It was in 1889, however, that Northrop conceived the idea of forcing a bobbin of weft into the shuttle without stopping the loom, thereby replenishing the weft supply in the loom automatically. Northrop realised that in order to do this it was essential that the shuttle should be so designed as to allow for free entry of the full bobbin and ejection of the empty bobbin, at the same time having the necessary means for holding the full bobbin securely after it had been placed in the shuttle. It was also necessary to supply means in the shuttle for automatically threading up the weft yarn. For this purpose a special shuttle was designed, having what is known as a " spring jaw " for carrying the bobbin, and a " self-threading eye " through which the weft yarn passed during the weaving process. Together with this shuttle it was necessary to design a suitable carrier for the weft yarn, and this eventually comprised a wooden bobbin with suitable rings, whereby it could be clipped in the spring jaw in the shuttle.

The next problem was to take care of the two ends of weft at the selvedge of the cloth, one of which was from the outgoing empty bobbin and the other from the new full ingoing bobbin. Northrop arranged this by means of a cutter mechanism incorporated in the temple which held out the cloth, ensuring that the weft ends were cut as near the selvedge as possible.

AUTOMATIC WEFT SUPPLY

It was now time to develop the automatic weft supply, and Northrop designed a rotary magazine or battery for holding a supply of full bobbins and this arrangement is incorporated in every single-shuttle automatic bobbin-changing loom today. By the end of 1891, Northrop had perfected his magazine and also a mechanism known as a " shuttle protector " which was designed to prevent the loom from trying to insert a new bobbin into the shuttle, if the shuttle was not exactly in the correct position for receiving the bobbin.

As a result of these inventions it was obvious that one operative would be able to supervise very many more looms, but Northrop and his colleagues realised that if the operative attended more looms, she would not be able to give the same careful attention to possible breakages in the warp yarn, and there would consequently be serious possibilities of producing more imperfect cloth. It was important, therefore, to design some mechanism which would immediately detect a breakage in a warp end and stop the loom. It was not until 1894 that the first automatic warp-stop motion was completed, and the time and money spent in developing this motion were considerably greater than for any of the previous motions just discussed.

In August 1894, the first Northrop Looms were sold to the Queen City Cotton Mills in Burlington, Vermont. This was an appreciable order, including 792 looms, and it spoke very well, both for the inventor's genius and for the workmanship put into these looms that, at the end of 1914, 424 were still running with 16 looms per weaver.

DEVELOPMENT OF THE NORTHROP LOOM

The advent of the Northrop automatic loom was so important that arrangements were made over 45 years ago for these looms to be made under licence in Europe. From these beginnings the automatic loom has developed from a narrow plain single-shuttle loom to the well-known makes of fully-automatic single-shuttle and multi-shuttle looms, built in any width from 20 inches to 155 inches, and suitable for applying to almost any section of the weaving trade. It is obvious that, in the early stages, the automatic loom should be used for weaving the most simple cloths, and it is extraordinary how to this day there are many engaged in the textile trade who believe that automatic weaving machinery is only applicable to a limited range of plain simple fabrics. During the last 50 years, however, there have been many improvements and refinements in the design and manufacture of automatic looms. Few of the changes may have been spectacular—none of them has marked an epoch in textile history—yet some of them are as important, all of them collectively more so, than the original invention.

It is most interesting to study the development of the automatic

loom in America, in Europe and in Great Britain. As with all other machinery, development has been, and is, dependent on many factors, such as the raw materials to be used, the attitude of labour towards mechanisation, and the quality of the product demanded from the machines.

In America today almost the whole of the loom-making industry is covered by two manufacturers. There have been others who are now out of business, and there are others trying to come in, but history will decide their fate. Of these two well-known makers, the Draper Corporation manufacture only single-shuttle looms for the cotton and rayon trade, and Crompton & Knowles Loom Works manufacture only multi-box looms, suitable for cotton, rayon and wool. The fact, therefore, that these two firms are specialists, each in their own field, makes it possible for their method of loom production and loom development to be greatly modified.

This specialisation by these two loom-makers is further intensified by the set-up of the American weaving industry where there are both large and small units producing one or two qualities of cloth only. It immediately follows that the loom maker can secure orders for his machines which cover a large number of looms of one specification, and this is a very great advantage when it comes to the actual manufacture of the looms.

EFFECT ON PRODUCTION

From the very beginning the introduction of the automatic loom into American weaving mills was a rapid process of change-over and expansion, and the ordinary non-automatic loom was fairly quickly eliminated. In the Draper Company's publication " Cotton Chat " of December, 1906, the writer states : " I found one mill in the South where 16 weavers were running 30 Northrop looms each, on sheetings, without assistance, obtaining an average of 93%. At another mill they averaged 22 print looms to the weaver throughout the whole mill, and they reached 100% production since the looms were running overtime sufficient to cancel the actual loss made during the regular 11 hours of work." By December, 1907, the Draper Company reports : " In our own plant we found it perfectly easy to keep a steady output of 500 looms per week for many months. There is no longer any question in the majority of mills as to the necessity for Northrop looms. The purchases are only governed by the amount of capital available."

So rapid was the development that in June, 1908, the Draper Company's Works contained 27 acres of floorspace, and practically the whole output from these works was devoted to single-shuttle Northrop automatic looms and accessories.

As its use increased throughout the American mills, it was obvious that the automatic loom would be applied to an ever-

widening range of fabrics. With this development it was natural that a higher quality of woven cloth would be required, and it was towards this end that further developments in loom design were made. Controlling the weft yarn is always one of the major problems in weaving, and particularly so in weaving on automatic looms. It is important not to damage the weft yarn by any of the mechanisms, and having adjusted a mechanism it is important that it should retain its " setting " accurately over long periods. On every automatic loom there is what is known as a " weft feeler motion ", which is used to determine when the weft package in the shuttle is nearly exhausted and bring into operation the weft replenishing motion. Weft feelers have been designed in all sorts of shapes and sizes, and different principles have been applied. It was in 1926, however, that the Draper Corporation invented what is now universally known as the " midget feeler ". This is the simplest form of weft feeler mechanism that could possibly be conceived. It is sensitive, it is kind to the weft yarn, and it completely fulfils the function for which it was designed.

It is always possible to damage a piece of woven fabric by lashing-in or trailing-in the weft ends from the outgoing or the ingoing bobbin after the weft change. In order to control these ends the Draper Corporation developed the Stafford Thread Cutter which works in conjunction with the Temple Thread Cutter. This was introduced in 1928 and was immediately applied to all the Draper Corporation automatic looms. This Stafford Thread Cutter has now become as essential as the midget weft feeler motion for making perfect cloth.

MORE LOOMS PER WEAVER

Up to 1930 the keynote of progress in the American weaving industry for the purpose of lowering weaving costs was " more looms per weaver." During the first quarter of this century each year saw a better-built Northrop loom—one improved device after another reduced the manual labour of the weaver and simplified the work of all the operatives in the Weave Room. As the looms improved and weaving defects from loom failure decreased, weavers were able to run more and more looms, first 16, then 32, 50, 72, 100. It then appeared that there was a practical limit—in the vicinity of 100 looms—to the number of looms per weaver, due not to the amount of work the weaver had to do, but rather to the ground she had to cover and the necessity of bringing her, without too much delay, to the loom that had stopped. With better looms and better yarn it was easily possible to calculate, on the basis of the number of warp ends that break per hour, that one weaver could handle more than 100 looms, but the distance she had to travel in order to do this made it impracticable. It then became a question of whether progress in the art of weaving could

advance still further. Was it impossible to make any more reductions in weaving costs? There could only be one answer—with opportunities closed to "more looms per weaver" why not "produce more per loom"? More production per loom involved a higher loom speed. Could looms be built so much better that they could run at higher speed? At the end of 1931 the Draper Corporation answered this question by putting on the market their first high-speed loom, and today they have the well-known group of "X" model looms, which are all single-shuttle high-speed looms, each built and designed for a specific range of single-wefted fabrics.

With higher loom speed varying anything from 190 to 200 and 220 revs. per minute, the increase in production per loom grows from 10% to 15% and 20% above previous production figures, while the number of looms per weaver remains the same. With increased production per loom grew the demand for larger warp beams behind the loom, and larger rolls of cloth in front of the loom; and, from the commonly accepted 18″ diameter beam, capacity grew until beams were 22″, 24″ and 26″ diameter, carrying 55% and 100% more yarn. It must be emphasised here, however, that the successful operation of automatic looms at these high speeds is ultimately dependent entirely on the quality of the warp and weft yarn, and the class of fabric to be produced.

PARALLEL AMERICAN WORKS

For the purpose of this survey the development of the Draper Corporation single-shuttle Northrop loom has been discussed in some detail. Running parallel with this Company's production in America is that of the Crompton & Knowles Loom Works, specialising exclusively in the multi-shuttle, multi-box automatic looms for weaving with up to four different colours or qualities of weft yarn. The growth of the American weaving industry, the improvements in yarn qualities, the increasing demand for better fabric, the ever-rising wages and the replacement of out-of-date machinery, affected the products of the Crompton & Knowles Loom Works, so that the quality of the loom improved, the speed of the loom increased, and the machines were designed for larger capacity warp beams and rolls of cloth.

The development of the automatic loom in Europe and Great Britain has been rather different to the development in the United States of America. When the first Northrop looms were made under licence in Switzerland, France and England, they had to be modified to suit European conditions. The direction of rotation of the main crankshaft in American looms is opposite to that which has been adopted in Europe, and this fundamental difference affects almost every motion on the loom. The European loom makers, therefore, had to re-design the American invention so as to suit local conditions, and from the simple single-shuttle loom has grown, during the last

45 years, an increasing range and variety of fully-automatic looms for producing almost any kind of woven fabric. It would be impossible, within the scope of this paper, even to mention the various stages of development through which the products of the various automatic loom makers have grown.

DIFFICULTY OF EXPANSION

The proportion of automatic looms to ordinary power looms in Europe is very much less than in America. There is still a great deal of prejudice against automatic weaving machinery. In many cases the textile industry is very much older than in America, and the construction of the mill buildings will not allow for the installation of modern automatic machinery. The tremendous variety of different fabrics produced in small quantities within one unit or mill involves conditions of manufacture where the installation of automatic machinery either in the department preparing the warp and weft yarns, or in the weave room itself, is often quite impracticable. Over a period of years, therefore, much smaller units of automatic looms have been installed in European mills than will be found in the American industry, and in many cases, instead of the looms being installed for bulk production of one fabric, they have been installed for the purpose of producing a cheaper, but at the same time higher quality fabric. The fact that an automatic bobbin-changing loom does not stop to replenish the weft in the shuttle can, of itself, be the means of producing a fabric better than can be produced on an ordinary power loom where the weaver has to stop the loom and replenish the shuttle by hand. Many manufacturers, particularly in this country, depend on quality rather than on quantity for retaining their export market, and the development of the automatic loom reflects this tendency.

From 1902 to 1920 the automatic looms made in this country were all single-shuttle looms for weaving with one colour, or quality, of weft yarn. The loom was introduced for weaving plain cotton cloths and the principle of automatic weaving was not accepted as being applicable to anything else. Even today, there are many manufacturers who are surprised when they are shown samples of fancy fabrics produced on automatic looms. So great was the antagonism of operatives in the weaving industry to the automatic loom that up to about 1920 the maximum number of looms to which one weaver was allowed to attend was limited to 20. On a plain cloth, where the number of loom stoppages per hour were relatively few, this limitation in looms per weaver was a great deterrent to the manufacturer who installed high-priced automatic machinery, carrying a heavy depreciation charge, in comparison

with the capital costs of an ordinary power loom. Today there is no limit to the number of looms per weaver in this country—that is, no agreed limit.

IMPORTANT FACTORS

The installation of automatic looms involves particular attention to the preparation of the warp yarn, and especially of the weft yarn, and it is only as attention is given to these important factors that real benefit can be obtained from the automatic loom. In the last few years, however, the manufacturing section of the industry as a whole has begun to pay attention to the importance of yarn preparation for the weaving process, and it is not surprising, therefore, that the proportion of automatic looms to ordinary power looms in this country is only 6%, both in the cotton and woollen industries. The comparative figures in America are 95% automatic looms in the cotton industry and over 70% in the woollen and worsted industry.

As compared with American practice, therefore, the British Northrop Loom Company up to 1939 had to cope with a large variety of small orders ; standardisation was difficult, and there were continuous changes in loom specification to meet conditions both in the home and export markets.

Rapid development took place, however, in the design and construction of the British automatic loom in the 20 years preceding the 1939 war, and special models of looms were produced for weaving heavy cotton canvas, ducks and beltings, flax canvas and hessians, fustians, terry towellings with up to four different colours in the weft, and woollen and worsted fabrics with single pick weft-mixing and up to four colours in the weft, rayon linings and rayon dress goods, lenos and furnishing fabrics operating with jacquards and up to four colours in the weft, linen damasks, elastic webbings and even cloths manufactured from spun glass.

In the last few years the textile industry in this country has become aware, as never before, of the absolute necessity of using modern automatic machinery in the Weave Room, as elsewhere. As a result, larger orders are being placed for automatic looms of one type, and it becomes increasingly possible for the automatic loom maker to concentrate on the possibility of repetition work on some of the standard models.

A very important point to consider when installing a section of automatic looms is that the modern automatic loom, equipped with large diameter warp beam, and with capacity for a large diameter roll of cloth at the front of the loom, obviously takes up more floor-space than its predecessor. It means that there is not sufficient room to replace 100 old looms with 100 new looms. Floorspace is required between the looms for handling the larger warp beam, and the spacing of the new machinery must be carefully considered. As a

result, any existing lineshafting for driving the looms is of no further use, and every new automatic loom must be equipped with its own motor. In this country and on the Continent, it is usual practice to drive the looms from the motor through vee ropes where the electric power supply is on the recognised standard of 50 cycles. In America, on the other hand, where the power supply is on a 60 cycle, the higher speed of the loom motor does not allow for transmission by vee ropes, and therefore most looms are driven through gearing direct on to the main shaft or an auxiliary shaft. The modern practice on the British automatic loom is for the loom motor to start and stop with the loom. The motor is, of course, specially wound for this purpose, and the loom is equipped with suitable electric switches, so that there is no necessity for the operative to turn the loom either forwards or backwards by hand ; everything is done electrically. Any precision automatic machine takes more power to drive than its simpler non-automatic counterpart and the automatic loom is no exception, but as each machine is driven by its own electric motor, maximum efficiency is obtained, and the cost of driving power per unit of cloth produced is probably a good deal lower than in a Weave Room where the machinery is driven by lineshafting with unknown frictional losses and power lost in belt transmission.

PRESENT STAGE OF DEVELOPMENT

The present stage of development of the automatic loom can briefly be summarised as follows. The American loom makers are producing high-speed precision machines for a textile industry where bulk production of any one fabric is maintained in individual mills. In the design of their looms the Americans have adhered to the principle of controlling the raising of the warp ends from above the warp, and they continue to use the loom top and overhead shedding mechanism. In Europe, including Great Britain, automatic loom manufacturers are also producing precision weaving machines, but they do not stress the requirement of high loom speed. The looms are for specialised and high quality production in a very much more varied form. The British loom maker, like the American, has maintained the overhead shedding mechanism with either single or double arch loom top. The Continental loom makers, on the other hand, are developing the practice of building looms without any top gear at all, and the shedding mechanism is operated either from the side of the loom or from below. This difference in design is interesting but probably not nearly so important as it is claimed to be.

What of the future ? For hundreds of years woven cloth has been produced along the same elementary principles of throwing a shuttle across the loom between the alternating top and bottom

layers of warp yarn, and each pick of weft beaten up into the cloth after each successive passage of the shuttle across the loom. Is cloth still to be woven this way during the next hundred years and after, or will some other method supersede what is now accepted as standard practice?

The history of weaving shows that man's inventive genius has been working continuously on the problem of producing a woven textile, and there are definite cycles during which certain ideas are reawakened and brought to the front and hailed as something entirely new. The technical and lay press at the present time are once again full of these ideas and we read of shuttleless looms, pneumatic looms, the magnetic control of the shuttle, and so forth. None of these conceptions is new, but because an idea has been exploited and given up in the past it does not mean that the next time it is brought forward it must again be a failure. Other sciences, other techniques, are developing all the time, and raw materials are available today which were not available 10, 15 or 20 years ago. It may well be, therefore, that cloth will be woven by means other than a shuttle flying through space, negatively controlled, at speeds over 30 miles an hour.

SHUTTLELESS WEAVING

One of the most interesting inventions which is being developed and watched with renewed interest at the present time is shuttleless weaving. This may be carried out by means of rapiers which are positively controlled and mechanically fed into the loom one from each side, so that the giver rapier hands the pick of weft to the taker rapier, laying a single pick of yarn across the loom as the rapiers move outwards. Another arrangement for shuttleless weaving is the rapid propulsion in sequence of a series of weft carriers, the function of each carrier being to lay one pick of weft across the loom in rotation. The weft is drawn from a large supply of yarn, each successive pick being automatically cut to length and drawn into the fabric. This particular machine in its present form is claimed to be capable of producing wide fabrics at very high speed, but so far they are fabrics using only one quality of weft.

The use of compressed air, hydraulics and electronics are all being demonstrated in one form or another as being applicable to weaving machinery. It is much too early yet to estimate with what success these experiments will be applied commercially.

An automatic loom, unlike a motor car or piano, has no intrinsic value. An automatic loom is a means to an end and that end is a perfectly woven fabric. An automatic loom is of value to the manufacturer just insofar as it will produce the best quality cloth at a price which will enable him to sell at a profit in a competitive world market. The prices of all textile machinery are low when compared

with machinery used in other industries. There is a reason for this low cost. It is found in the large number of machines of each kind required to equip a mill. The machine maker has been compelled to find a way to design and build machines fully equal to the part they are called upon to perform, and yet that can be sold at a comparatively low cost ; otherwise the textile industry, with its average of narrow profits, could not have lived and paid dividends on the investments that would have been required. Competition between loom makers has contributed, but the real necessity has been the compelling force in keeping prices low.

COST CONSIDERATIONS

To many, however, the automatic loom has always seemed a high-priced machine, chiefly because it has been measured by the price of the ordinary common non-automatic loom. An automatic loom, however, is designed to perform continuously and accurately many of the functions that would otherwise have to be carried out by the weaver. The fact that the automatic loom has mechanisms designed to avoid the production of faulty cloth means that the weaver, who is now a supervisor over a number of machines, is relieved of the anxiety and worry attached to ordinary loom weaving. If the work is being taken from the weaver and put on to the machine, it is only reasonable to suppose that the machine must cost considerably more than the non-automatic counterpart. Provided, therefore, that the output from that automatic machine is equal to, or greater than, that of the ordinary power loom, then justification for an increase in price for the automatic loom is fully maintained. Offsetting the higher depreciation charge following the installation of expensive automatic weaving machinery is the tremendous saving in the weekly wage bill. The manufacture of cloth becomes a scientific process where the efficiency at every stage can be measured, as it is a " machine production ". The efforts of the human operative, and his efficiency, are immeasurable, and at this stage in the twentieth century it is an insult to expect an intelligent textile operative to stand day in, day out, between four or six ordinary power looms, replenishing shuttles with weft yarn. With automatic weaving machinery the weaver becomes a supervisor of cloth production, where the work load is lighter, the conditions cleaner, and the pay better.

CONCLUSION

In conclusion, therefore, it is obvious that, except for a very small percentage of looms, cloth production throughout the world will be maintained on one or other type of fully-automatic weaving machines. Just as there are still hand looms in existence, producing certain specialised fabrics demanding the skill of a craftsman, so there will always be the

necessity for a few ordinary power looms, but for the rest they must be automatic looms. The ingenuity of the loom designer will continue in the effort to produce still better machinery. It is possible to apply to a loom many different and sometimes useful mechanisms, but whatever changes take place there are three essentials by which an automatic weaving machine must be judged : firstly, accessibility —the mechanic responsible for maintaining the machines must have easy access to every component which requires adjustment ; secondly, versatility—an automatic loom produces a range of cloths, and the various mechanisms on the loom must be capable of alteration and adjustment for each condition ; and thirdly, simplicity—the function of an automatic loom is to produce perfect cloth, and an operative who is supervising a number of machines can rightly demand that they should be as simple as possible. Accessibility, versatility, simplicity, and the most important of these is simplicity.

(Illustrations to this Paper appear on pages 312-318)

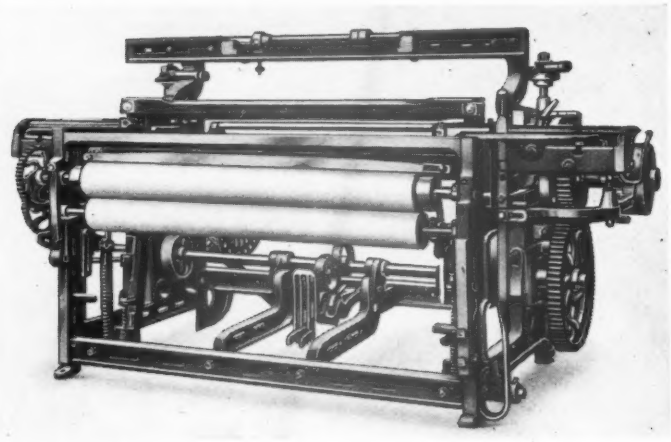

FIG. 1. A typical example of a single-shuttle non-automatic loom.

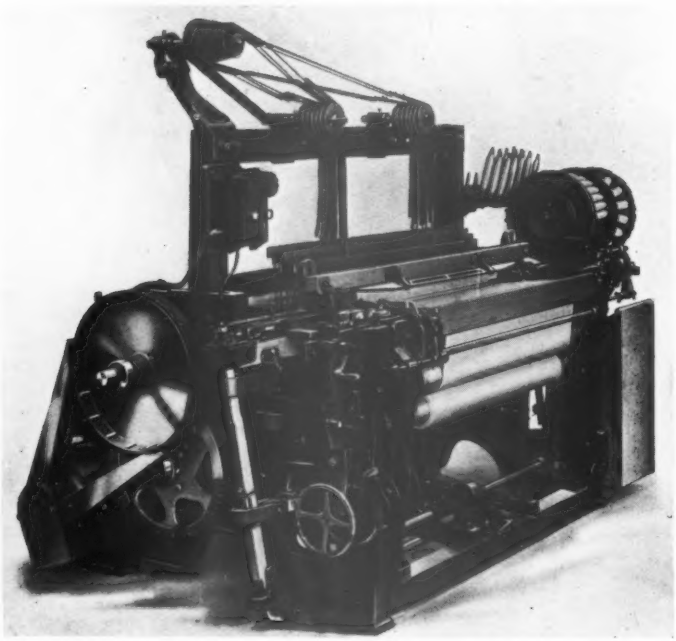

FIG. 2. A modern single-shuttle Northrop fully automatic loom.

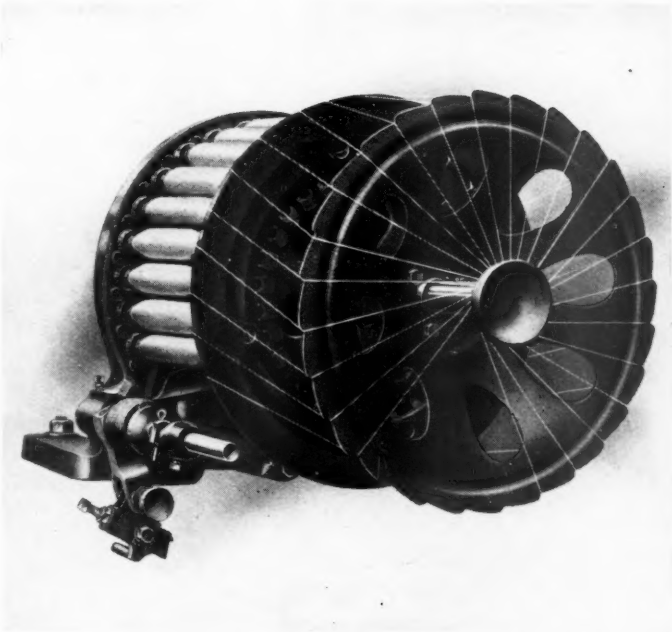

FIG. 3. The Northrop Battery for holding the supply of weft bobbins.

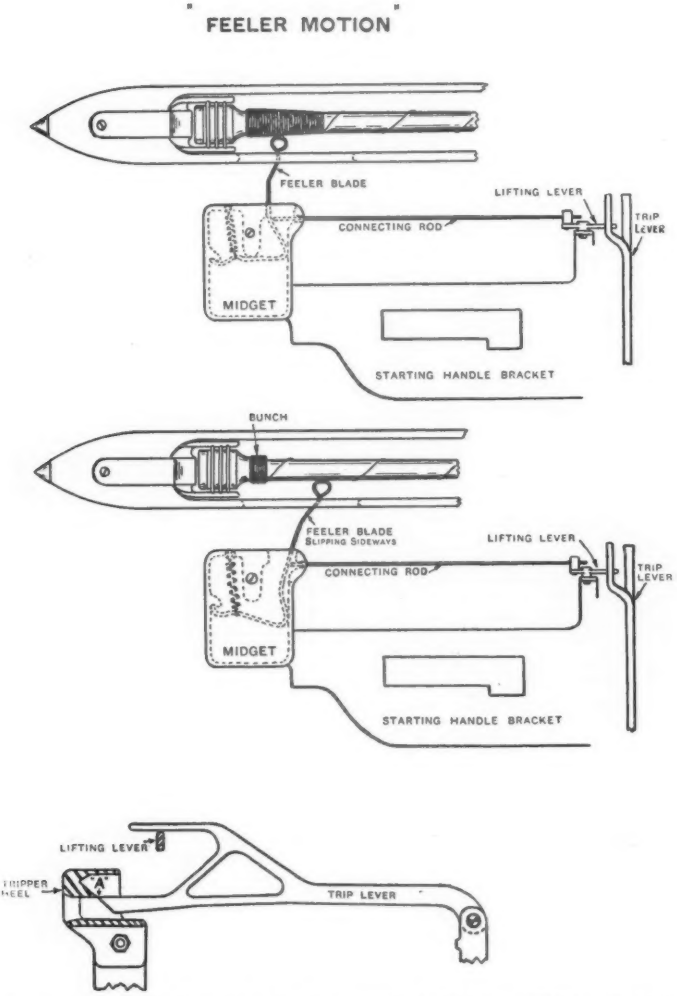

FIG. 4. Automatic Weft Feeler Motion showing the Northrop "Midget Feeler".

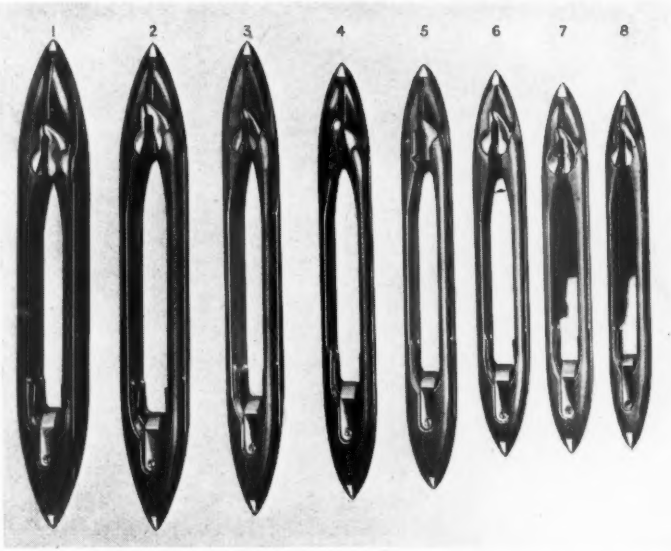

FIG. 5. A selection of Northrop Loom Shuttles, showing the spring jaw and the self-threading shuttle-eye.

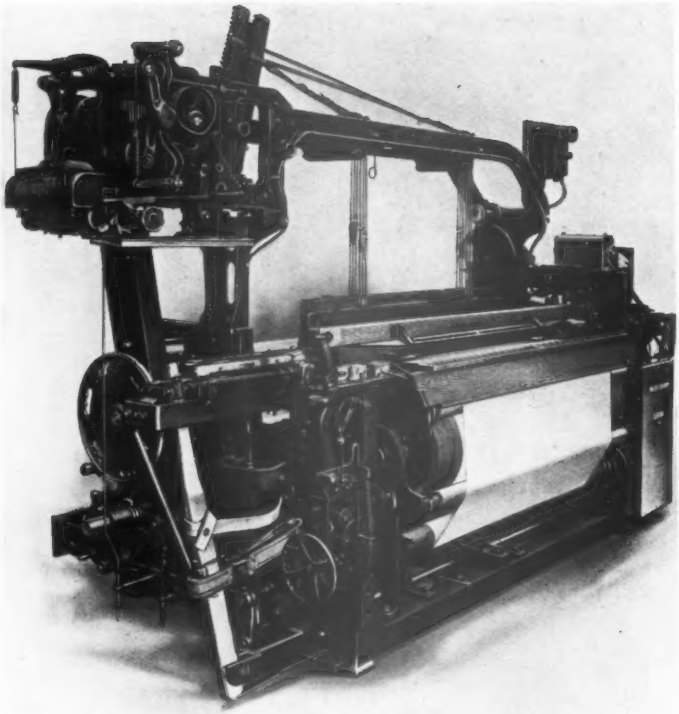

FIG. 6. Northrop automatic loom for weaving crepes and fancy fabrics with two qualities of weft.

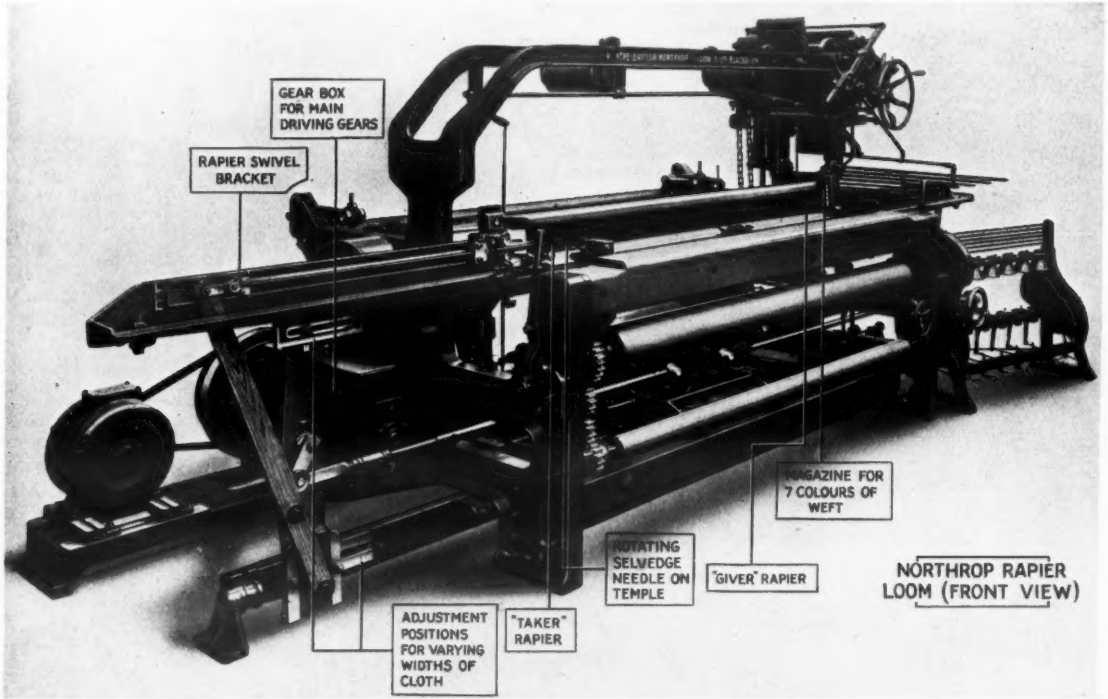
GEAR BOX FOR MAIN DRIVING GEARS
RAPIER SWIVEL BRACKET
MAGAZINE FOR 7 COLOURS OF WEFT
ROTATING SELVEDGE NEEDLE ON TEMPLE
"GIVER" RAPIER
NORTHROP RAPIER LOOM (FRONT VIEW)
ADJUSTMENT POSITIONS FOR VARYING WIDTHS OF CLOTH
"TAKER" RAPIER

FIG. 7. The Northrop Rapier Loom, a fully automatic shuttleless loom for weaving speciality woollen and worsted fabrics.

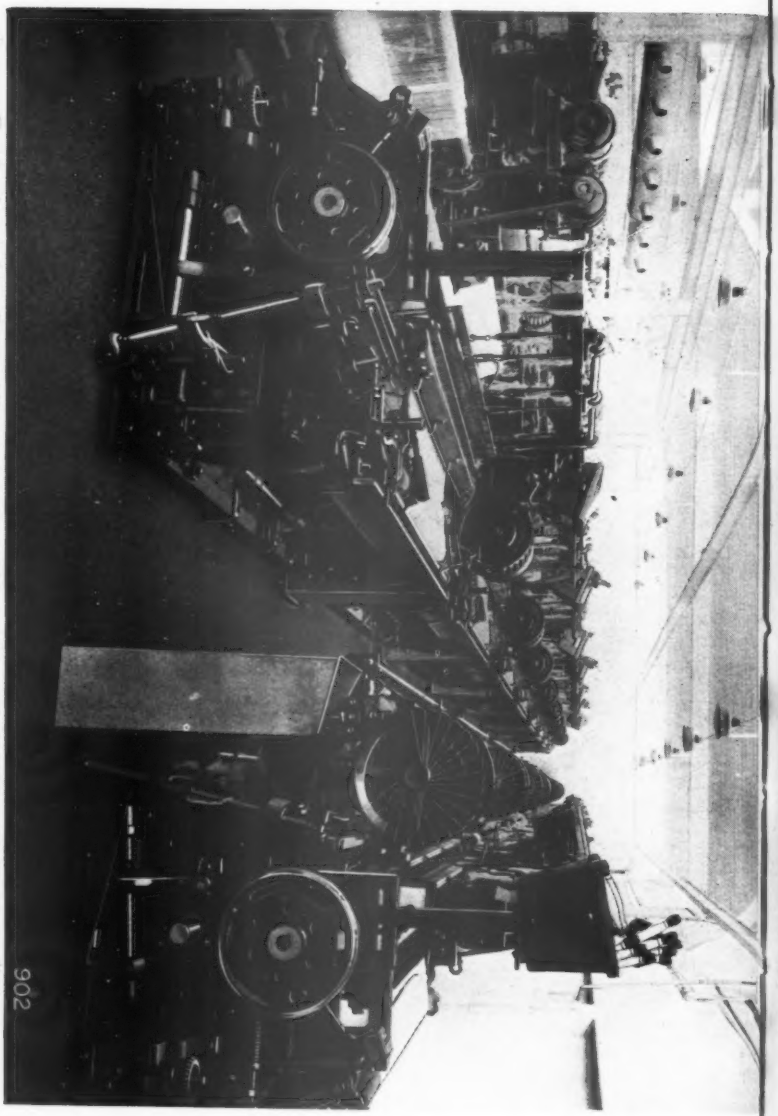

FIG. 18. A typical installation of Northrop automatic looms—all looms individually driven and well-spaced.

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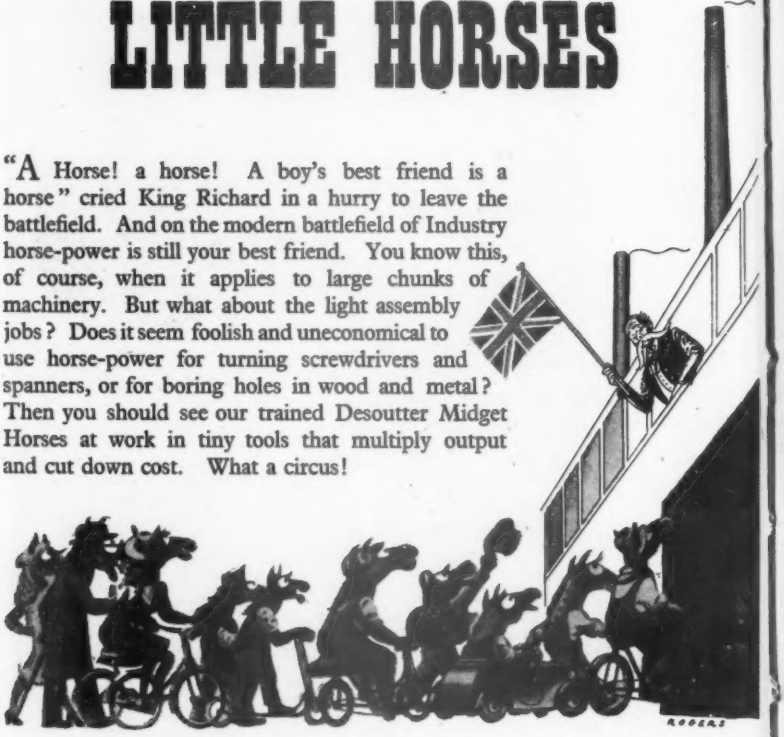

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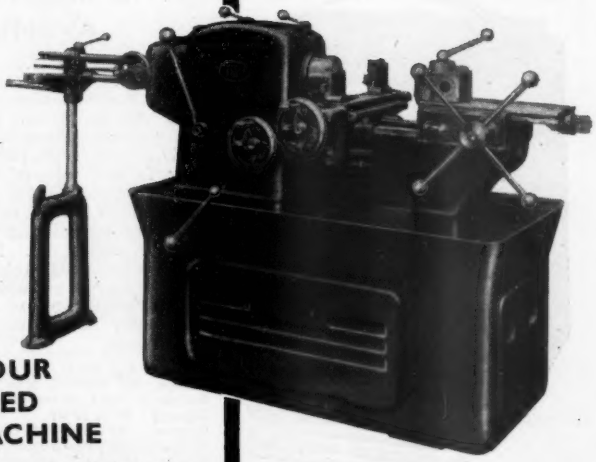

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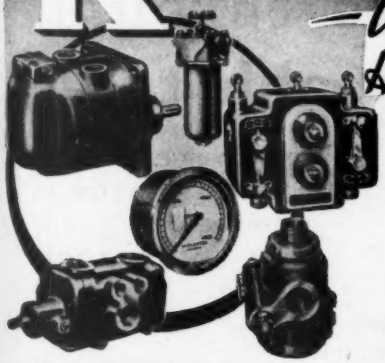

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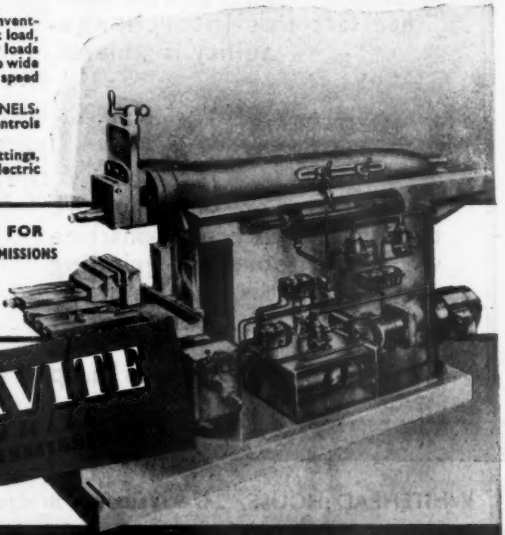

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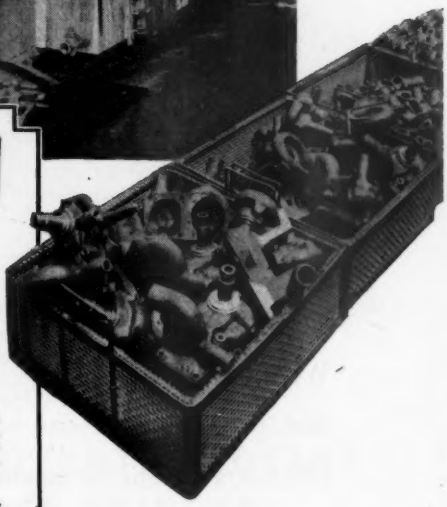

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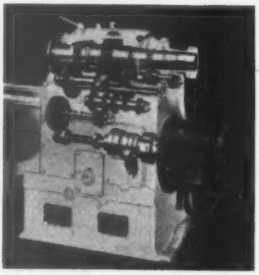

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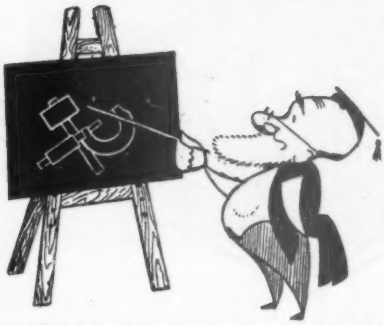

Will Might, the Mill-wright
——and the PROF.
Set-too No. FIVE

"ON the blackboard today, we have a device which at first sight may appear familiar. I want you, Will Might, and the rest of you to consider the breakdown of the symbol into B.F. and F.I. on the one hand, and B.R.A.I.N. on the other..."

"Yes, Prof. : . . . ."

"It is an inequation. The first part is of significance to the ham-fisted of the first world war, and the latter part familiar in my experience, to very few indeed. An 'inequation' I may explain, is an invention of my own; it represents a relationship in contrasts. An ordinary belt and a Hendrys', for instance. You, Bill, on the one hand, and myself on the other; ignorance and intelligence; the sciolist and the savant; negative and positive poles or perhaps I might say the down and the up . . ."

"You are the up, I suppose, Prof. up the pole, Hah! Hah! But you're right about Hendrys'".

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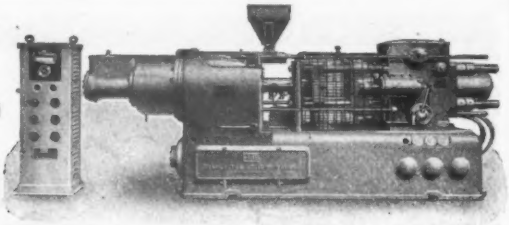

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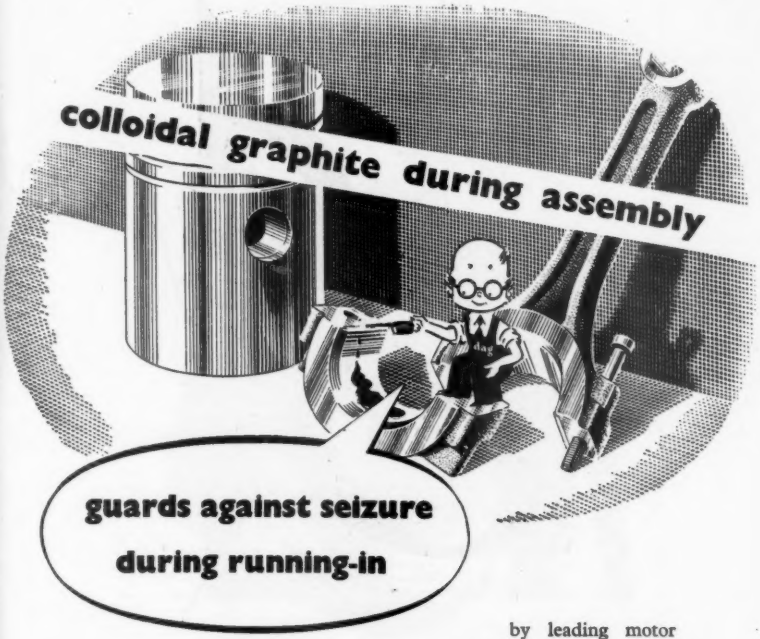

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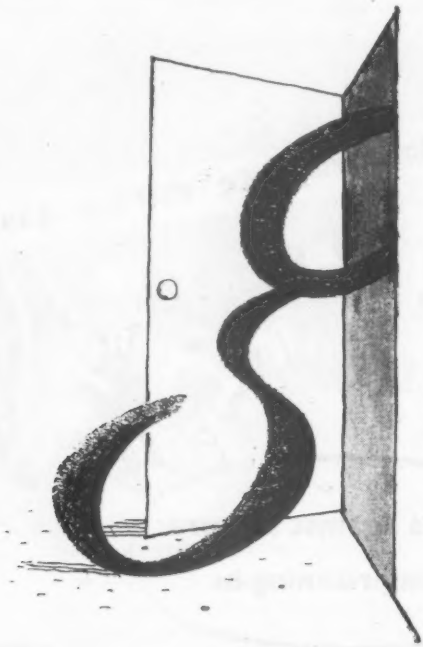

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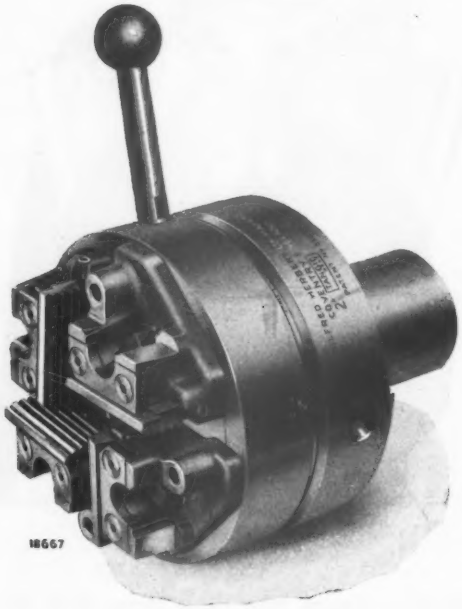

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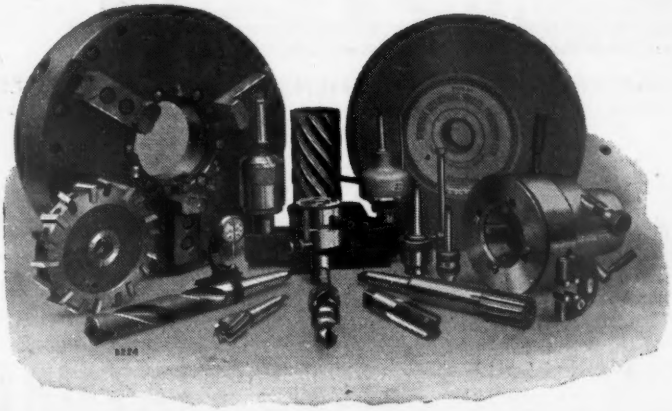

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TAYLOR 1239

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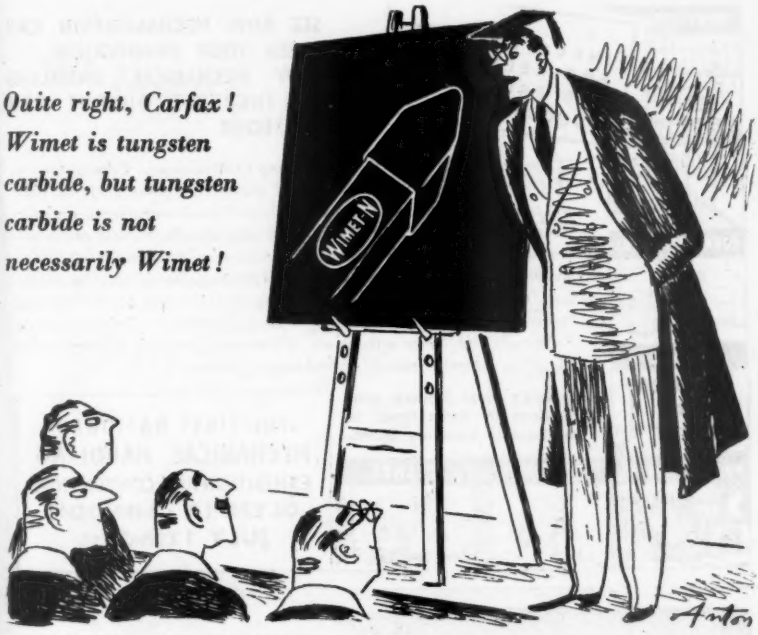

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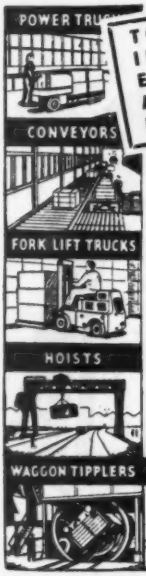

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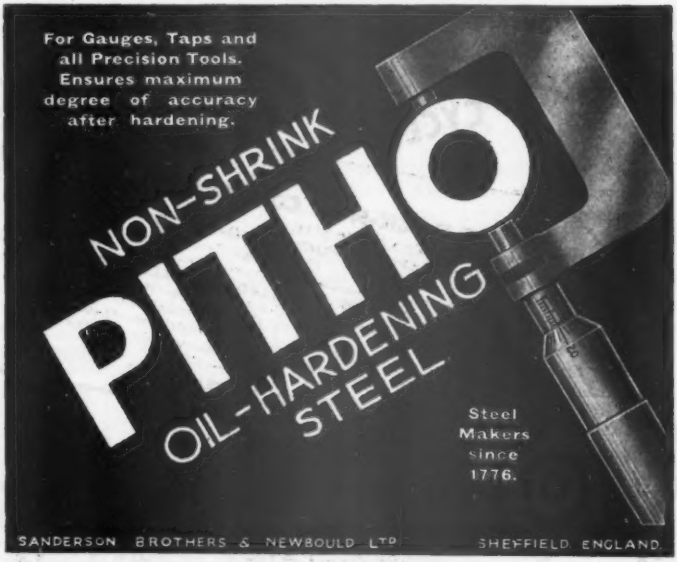
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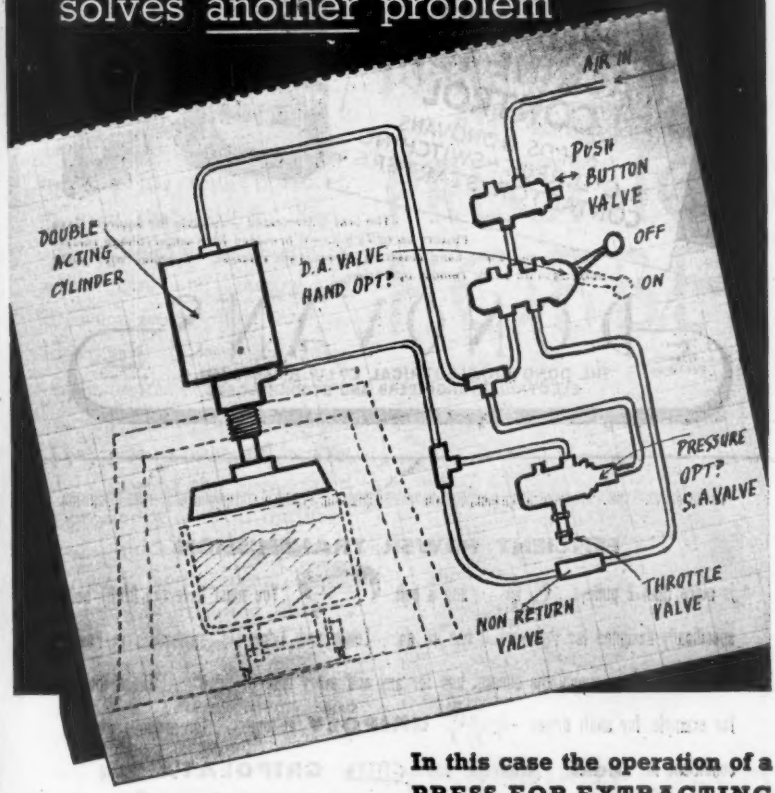

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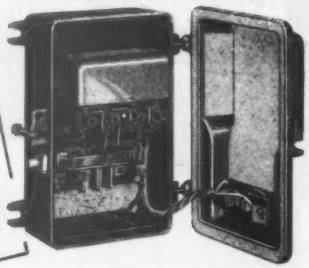

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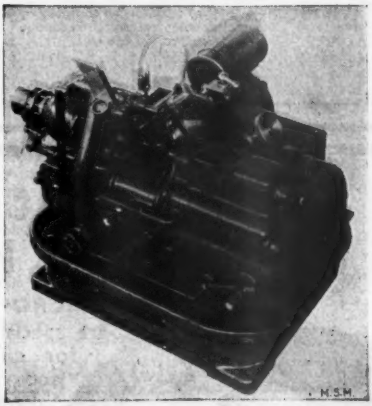

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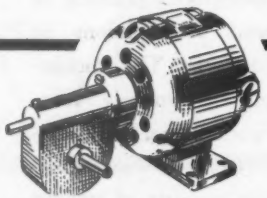

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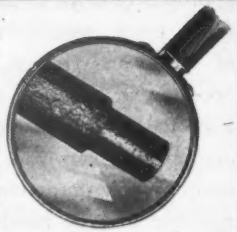

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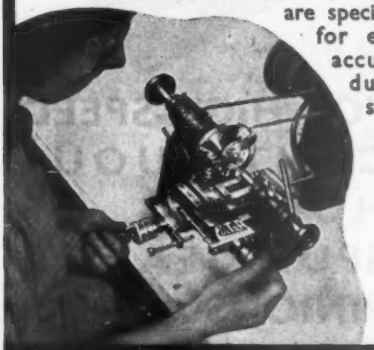

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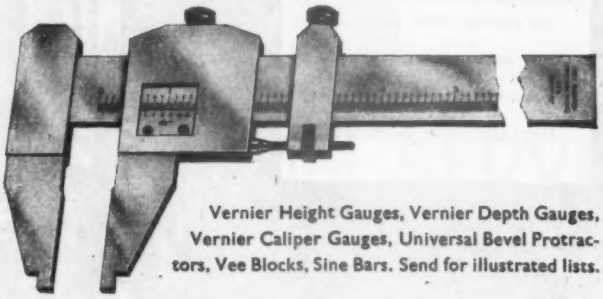

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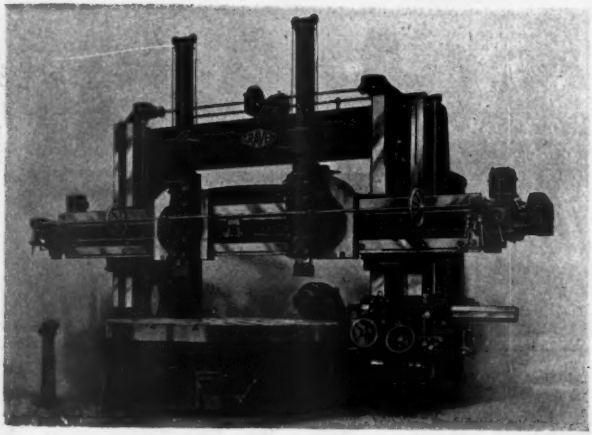

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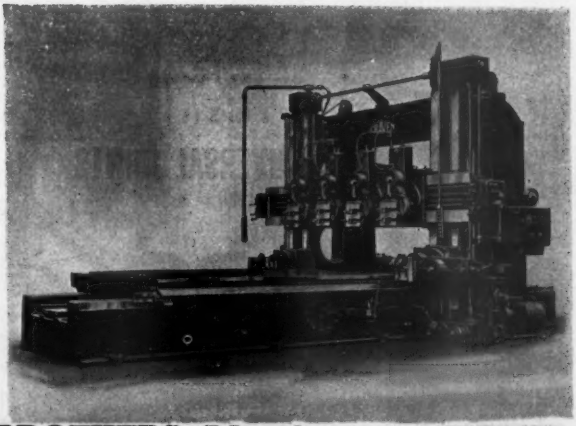

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INDEX TO ADVERTISEMENTS

	Page
Acheson Colloids, Ltd.	xxviii
Airmec Laboratories, Ltd.	xxxv
Arnott & Harrison, Ltd.	—
Asquith, Wm. Ltd.	—
Automatic Coil Winder Electrical and Equipment Co., Ltd.	xvii
Barber & Colman, Ltd.	xliv
Bilton's Abrasives, Ltd	—
Birlec, Ltd.	—
Bratby & Hinchliffe, Ltd.	xx
British Steel Founders' Association	xxxvi
Burton Griffiths & Co., Ltd.	xi
Carter Electrical Co., Ltd.	xlv
Catmur Machine Tool Corporation, Ltd.	xix
Churchill, Charles & Co., Ltd.	—
Churchill, H. & D., Ltd.	viii
Cincinatti Milling Machines, Ltd.	xlviii
Climax Rock Drill and Engineering Works, Ltd.	xlii
Collis, J. & Sons, Ltd.	—
Coventry Gauge & Tool Co., Ltd.	xiv
Craven Bros. (Manchester) Ltd.	l
Crittall, Richard & Co., Ltd.	—
Dawson Bros., Ltd.	xlvi
Dean, Smith & Grace, Ltd.	xxiii
Desoutter Bros. Ltd.	xv, xxx
Donovan Electrical Co., Ltd.	xliii
Drummond Asquith (Sales) Ltd.	ix
Electricars, Crompton Parkinson Ltd.	xxxix
E.M.B. Co., Ltd.	xxvii
Exors. of James Mills, Ltd.	xl
Firth, Thos. & Brown, John Ltd.	—
Flame Hardeners Ltd.	li
Fletcher Miller, Ltd.	xxvi
Glover, J. & Sons, Ltd.	xxxv
G.P.A. Tools & Gauges, Ltd.	xxxiii
Grey & Rushton (Precision Tools) Ltd.	xlix
Guylee, Frank & Son, Ltd.	*Inside Back Cover*
Hendry, James Ltd	xxv
Herbert, Alfred Ltd.	xxxi, xxxii
High Duty Alloys, Ltd.	xxix
Holman Bros. Ltd.	*Back Cover*
Hoover, Ltd.	xii
Hordern, Mason & Edwards, Ltd.	iv
Imperial Chemical Industries, Ltd.	—
Kaye, E. & E., Ltd.	xxxvii
Keelavite Rotary Pumps & Motors, Ltd.	xviii
King, Geo. W. Ltd.	—
Lang, John & Sons, Ltd.	vi
Lewis & Tylor, Ltd.	xliii
Lloyd, Richard Ltd.	—
Lund, John Ltd.	xxiv
Mechanical Handling	xxxix
Ministry of Fuel & Power	—
Mollart Engineering Co., Ltd.	—
Morgan Gears, Ltd.	lii
Motor Gear & Engineering Co., Ltd.	li
Newall, A. P. & Co., Ltd.	v
Newall Engineering Co., Ltd.	xxxiv
Norton Grinding Wheel Co., Ltd.	—
Parkinson, J. & Son	—
Perry Barr Metal Co. Ltd.	—
Protolite, Ltd.	—
Pryor, Edward & Son, Ltd.	—
Pultra, Ltd.	xlv
Randalrak, Ltd.	—
Ratcliffe Tool Co., Ltd.	xlvii
Reavell & Co., Ltd.	xxi
Sanderson Bros. & Newbould, Ltd.	xli
Scottish Aviation Ltd.	—
Sheet Metal Technicians, Ltd.	lii
Sheffield Twist Drill & Steel Co., Ltd., The	—
Snow & Co., Ltd.	xxii
Sunbeam Anti-Corrosives, Ltd.	xlvii
Sundstrand Pneumatic Sanders (Britain) Ltd.	—
Taylor & Jones, Ltd.	—
Technically Controlled Castings Group, The	xlix
Tecnaphot, Ltd.	xxxvii
Timbrell & Wright Machine Tool & Engineering Co., Ltd.	xvi
Towler Bros. (Patents) Ltd.	—
Triefus & Co. Ltd.	iii
Unbrako Socket Screw Co., Ltd.	*Inside Front Cover*
Universal Tools, Ltd.	xli
Vaughan, Edgar & Co., Ltd.	—
Ward, H. W. & Co., Ltd.	vii
Watts, E. R. & Son, Ltd.	—
Wickman, A. C. Ltd.	xiii, xxxviii
Williams & James (Engineers) Ltd.	—
Wolverhampton Die Casting Co., Ltd.	x
Zinc Alloy Die Casters Association	—

Page
..xxxvii
xviii
—
vi
..xliii
—
xxiv
..xxxix
—
—
..lii
li
v
..xxxiv
—
—
—
—
—
xlv
—
xlvii
xxi
xli
—
lii
—
xxii
xlvii
—
—
xlix
xxxvii
xvi
—
iii
t Cover
xli
—
vii
—
xxviii
—
x
—

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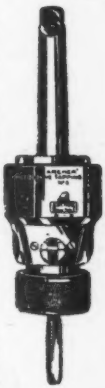

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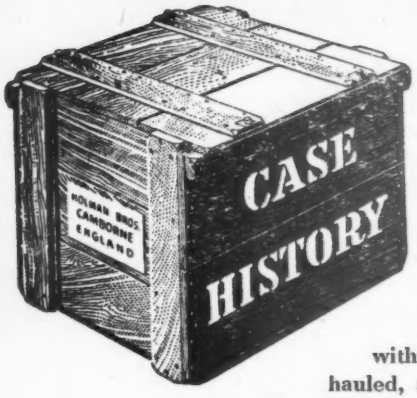

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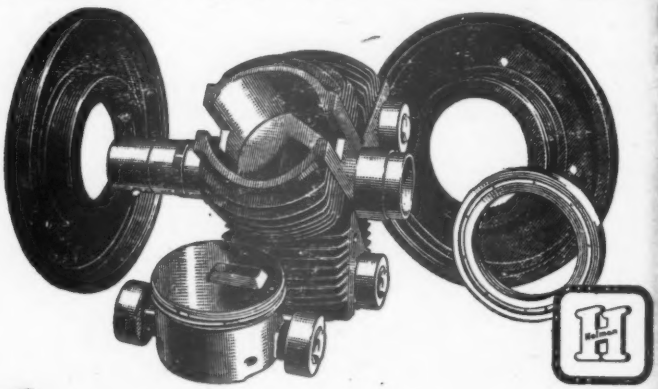

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